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REVIEW OF THE CANADIAN METAL FINISHING INDUSTRY,

CONSUMPTION OF RAW MATERIALS AND OPTIONS FOR WATER

POLLUTION CONTROL, 1975.

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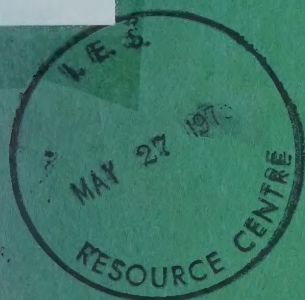
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Review of the Canadian Metal Finishing Industry

Consumption of Raw Materials
and Options for
Water Pollution Control



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Water Pollution
Control Directorate
March, 1975

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REVIEW OF THE CANADIAN METAL FINISHING INDUSTRY
Consumption of Raw Materials and Options for Water Pollution Control

prepared by

Inorganic Chemicals Program
Water Pollution Control Directorate
Environmental Protection Service
Environment Canada

Report No. EPS 3-WP-75-2
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ABSTRACT

This report reviews basic background information on the processes used in the Canadian metal finishing industry, its waste products and waste reduction practices. The information presented was obtained by a Task Force of industrial, provincial and federal government personnel as part of the preliminary work necessary to develop national effluent control requirements for the Canadian metal finishing industry. This material is based on a survey, in the form of a questionnaire, of the industry and numerous contacts with companies which responded to it; visits to metal finishing installations in various countries; extensive discussions with foreign agencies engaged in controlling effluents from metal finishing operations; and a review of the references cited.

RESUME

Le présent rapport est une analyse des renseignements de base sur les procédés pour la mise en forme des produits métallurgiques dans les industries canadiennes, les déchets qu'elles produisent et les méthodes de réduction de la pollution qu'elles emploient. Les renseignements qu'il renferme ont été obtenus par un groupe d'étude formé de représentants de l'industrie et des gouvernements provinciaux et fédéral, dans le cadre d'un travail préliminaire nécessaire à l'élaboration de normes nationales anti-pollution à l'intention de l'industrie canadienne de la mise en forme des produits métallurgiques. Ces données proviennent d'un questionnaire qui a été distribué à travers les industries et des nombreux échanges qui ont eu lieu avec celles qui y ont répondu, de visites à des installations de mise en forme de différents pays, de discussions prolongées avec des organismes étrangers chargés de la lutte contre la pollution créée par les opérations métallurgiques de mise en forme, et enfin d'une revue des références citées.

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	i
TABLE OF CONTENTS	iii
List of Figures	v
List of Tables	vi
1. INTRODUCTION	1
2. PROCESS DESCRIPTIONS	2
2.1 Mechanical Processes	2
2.2 Physical Processes	4
2.3 Non-metallic Coating	4
2.4 Chemical Processes	4
2.5 Electrolytic Processes	8
2.6 Wastewater Constituents	13
3. SURVEY OF THE METAL FINISHING INDUSTRY	17
3.1 Purpose and Method	17
3.2 The Questionnaire	19
3.3 Results	19
4. WATER POLLUTION PREVENTION	23
4.1 Substitution	23
4.2 Water Use	24
4.3 Control of Accidental Dumps and Leaks	26
4.4 Drag-out and Drainage	27
4.5 Reclamation	28
4.6 Regeneration	28
4.7 Solution Concentration	29
4.8 Supervision	29
5. IN-PLANT WATER POLLUTION CONTROL	30
5.1 Water Uses	30
5.2 Stream Separation	31
5.3 Water Re-use	32
5.4 Recovery of Chemicals and Metals	34
5.5 Concentrated Dumps	41

TABLE OF CONTENTS (CONT'D)

	<u>Page</u>
6. EXTERNAL CONTROLS	43
6.1 Cyanide Destruction	43
6.2 Chromium Reduction and Removal	46
6.3 Other Metals Removal	48
6.4 Liquid-Solid Separation	50
6.5 Oils, Grease and Cleaners	53
6.6 General Information	54
7. EXISTING LEGISLATION	60
REFERENCES	66
GLOSSARY	67
APPENDIX A - QUESTIONNAIRE AND TABULATION OF INFORMATION	79
APPENDIX B - REPORT OF THE PLANT POLLUTION SUBCOMMITTEE, AUTOMOTIVE PARTS MANUFACTURER'S ASSOCIATION	129

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1	Schematic Flow Sheet of a Copper-Nickel-Chrome Plating System Without Waste Treatment	16
2	Recovery of Plating Process Chemicals by Closed Loop Evaporating Equipment	38
3	Manual Batch Treatment System for Chromium, Heavy Metals and Cyanide Wastes	56
4	Automated Continuous Flow Treatment for Chromium, Heavy Metals and Cyanide Wastes	57
5	Integrated Treatment System	58
6	Ion Exchange and Batch Treatment for Nickel-Chromium Wastewater	59

LIST OF TABLES

<u>Table</u>		<u>Page</u>
1	Typical Acid Plating Baths	10
2	Cyanide Plating Baths	11
3	Principal Constituents and Concentrations in Major Metal Finishing Processes - Untreated Effluents	14
4	Summary of Questionnaires Sent and Replies Received	21
5	Correction Factors	22
6	Foreign Legislation at Requirements for Metal Finishing Operations	61
7	Some English River and Local Authority Discharge Standards for Metal Finishing Operations	64
8	Examples of Consents to Discharge of Toxic Metals from Metal Finishing Operations to the Thames River	65

APPENDIX A

A.1	Companies Having Only Chemical Treatment of Surfaces: General Information	83
A.2	Companies Having Electroplating and Cyanide Hardening of Surfaces: General Information	84
A.3	Process Information	85
A.4	Companies Having Only Chemical Treatment of Surfaces: Available Information on Waste Disposal	88
A.5	Companies Having Electroplating and Cyanide Hardening of Surfaces: Available Information on Waste Disposal	89
A.6	Companies Having Only Chemical Treatment of Surfaces: In-plant Measures for Wastewater Pollution Control	90
A.7	Companies Having Electroplating and Cyanide Hardening of Surfaces: In-plant Measures for Wastewater Pollution Control	91
A.8	Companies Having Only Chemical Treatment of Surfaces: External Measures of Wastewater Pollution Control	92
A.9	Companies Having Electroplating and Cyanide Hardening of Surfaces: External Measures for Wastewater Pollution Control	93

LIST OF TABLES (CONT'D)

APPENDIX A (CONT'D)

<u>Table</u>		<u>Page</u>
A.10	Companies Having Chemical Treatment of Surfaces: Monitoring of Wastewater	94
A.11	Companies Having Electroplating and Cyanide Hardening of Surfaces: Monitoring of Wastewater	95
A.12	Consumption of Chemicals	96
A.13	Consumption of Chemicals by Metal Finishing Process	103
A.14	Number of Processes Responding in Table A.13	113
A.15	Consumption of Chemicals Expressed as Ions	112
A.16	Consumption of Metal Anodes by Electrolytic Process	123

1. INTRODUCTION

This review presents basic background information on the processes used in the Canadian metal finishing industry, its waste products and waste reduction practices. This information was obtained as part of the preliminary work of a Task Force composed of industrial, provincial and federal government personnel charged with developing national effluent control requirements for the Canadian metal finishing industry. Preliminary studies have produced a considerable amount of information which, being valuable and in large part original, could be useful to others outside the Task Force.

The material contained in this review is based on a survey, in the form of a questionnaire, of the Canadian metal finishing industry and numerous contacts with companies which responded to it; visits to metal finishing installations in various countries; extensive discussions with foreign agencies engaged in controlling effluents from metal finishing operations; and a review of the references cited. Several consultants and plant personnel in different countries were interviewed and their contributions are reflected in the content. Information and support was also received from the Automotive Parts Manufacturers' Association and the Industrial Waste Branch of the Ontario Ministry of the Environment. The Automotive Parts Manufacturers' Association has prepared a special report on plant pollution from the automotive industry; their report is included here as Appendix B.

This review is not intended to be a complete investigation into the area of metal finishing effluent control. The material has been organized into various sections dealing with the different aspects of metal finishing, and a minimal effort has been made to coordinate the material in these sections. It is addressed to people with a background in metal finishing and an interest in effluent control in Canada.

A special thanks is due to Mr. K.R. Coulter for his dedicated contribution in assembling this material under one cover.

2. PROCESS DESCRIPTIONS

2.1 Mechanical Processes

2.1.1 Sand blasting

Sand blasting, or more properly abrasive blasting, is a process where abrasive materials are directed at parts in order to clean them, give them a better finish, or otherwise change the surface characteristics. The wide range of abrasives used indicates that the method is no longer limited to the use of sand as a abrasive.

The abrasives may be applied dry, either mechanically or by air, or wet in a slurry. The operation is generally carried out in a cabinet and will range from infrequent cleaning or honing of tools to very high volume production.

The materials used for dry blasting will include steel shot; slag products; aluminum oxide; silicon carbide; natural products such as garnet and pumice; agricultural products, such as ground corn cobs; and glass beads. Dry blasting is usually preceded by a cleaning operation to prevent too frequent disposal of the abrasive.

In wet blasting the abrasive is suspended in a slurry which will contain a wetting agent, rust inhibitors, and anti-settling agents. As in dry blasting, pre-cleaning of the work pieces is usually done to minimize disposal frequency.

2.1.2 Tumbling

Tumbling or burnishing is a process performed by placing the work in a barrel and rotating it with or without abrasives, dry or wet.

Its purposes are to deburr, descale, polish, burnish or to dry production parts.

Submerged tumbling barrels are perforated and rotate in an open tank containing water, wetting and cleaning agents.

Disposal of this liquid with accumulated soil is necessary periodically, with the frequency dependent on production rates and amount of soil.

2.1.3 Vibratory finishing

When the volume of production permits, or particular shape of finish demands it, vibratory finishing is used as a preference to tumbling. As with tumbling the work being finished may be plastic, rubber, metal or ceramic.

Vibratory machines give an oscillating motion to the entire load which consists of the parts, abrasive media, water and chemical compounds. The media used in both tumbling and vibratory finishing include aluminum oxide, the most popular; silicon carbide; steel balls, and other steel shapes; corundum, and other natural abrasives; granite; limestone; and quartzite.

The liquids used in both tumbling and vibratory machines will vary in pH from 1 to 14. The acidic compounds are used for descaling or derusting. Alkaline liquids are used when metal removal by mechanical action is desired; neutral liquids are used when burnishing is required.

2.1.4 Polishing and buffing

These processes, along with grinding, describe the operations performed on workpieces using wheels and abrasives.

Grinding removes substantial quantities of material from the workpiece, polishing removes some material but leaves fine lines and buffing smooths the work and leaves a lustre.

Grinding operations use hard fabricated wheels containing a variety of abrasives, both natural and synthetic. The operation generates particles of grit from the wheel as it wears metal from the workpiece. Polishing is performed by wheels made of muslin, canvas, felt, or leather. Abrasive grains are attached to the wheel by proprietary adhesives or hide glues.

The most widely used abrasives for both polishing and grinding are aluminum oxide and silicon carbide. Some natural grits such as emery are used for specific purposes.

Continuous belts made of woven cloth with factory applied abrasives are widely used with the belt running over a cushioned contact wheel. Buffing wheels may be made of sisal, muslin, flannel, and occasionally wool. Chemical treatments are applied to the material to impart cutting characteristics or to increase wearability.

Abrasives used include natural products such as tripoli and synthetic aluminum oxide and silicon carbide.

In each of the above operations substantial exhaust systems are required and particles of abrasives, metal, cloth and lubricants are carried to cyclones or water scrubbers for removal. In the instance of scrubbers the resultant slurry must be disposed.

2.2 Physical Processes

Galvanizing or hot dip zinc coating is the most widely used physical process since it provides an inexpensive corrosion resistant surface. Aluminum coating of steel is finding increasing use, and lead and tin are also used.

In all of these applications the metal is prepared by cleaning processes that may include alkaline cleaners and will include hydrochloric and/or sulphuric acid for pickling and cleaning.

A typical sequence for galvanizing would be two 10% sulphuric acid dips, water rinse, zinc ammonium chloride flux dip and galvanize.

2.3 Non-Metallic Coating

Painting is the most widely used metal finishing process and its application is well understood. The various preliminary cleaning and precoat processes are covered below under chemical processes.

Plastic powder coatings have been finding increased usage and in many applications are replacing paint or metallic coatings. Preparation of the workpiece is similar to that for paint in its use of chemicals for cleaning and surface preparation.

Each of these processes has potential disposal problems in materials retained by water wash spray booths.

2.4 Chemical Processes

2.4.1 Degreasing, pickling, de-rusting (chemical cleaning)

Vapour degreasing is a process used to remove soils soluble in a solvent and other foreign matter which may be entrapped but which will be loosened by the solvent and washed away by the liquid action as the vapour condenses. The solvents most frequently used are trichlorethylene, perchlorethylene, and methylene chloride.

The accumulation of soil necessitates periodic cleanout of sludge. If volume is sufficient, the contaminated solvent may be recovered by distillation.

Soak cleaning. (a) Emulsifiable solvents, emulsion cleaners and diphasic cleaners are used to remove gross soil from the work. These contain petroleum or organic solvents. The operation is performed in tanks and the cleaners function by emulsifying and dissolving the solids, which largely settle to the bottom of the tank.

(b) Detergents which contain buffering salts, sequestering agents, dispersants, inhibitors, wetting agents and/or soaps are a second category of cleaners. Detergents wet, emulsify, disperse and solubilize the soil.

(c) Alkaline cleaners contain sodium hydroxide, silicates, and carbonates along with dispersing agents and surface active agents.

(d) Acid cleaners are used to remove oil and metal oxides and to produce light phosphate coatings. They may be either inorganic or organic, such as phosphoric acid or gluconic acid. They are used with water miscible solvents and organic wetting and emulsifying agents.

Pickling is primarily used to remove scale, rust and solder from a variety of metals. Acids used include nitric, hydrochloric, hydrofluoric, sulphuric, chromic, acetic, and phosphoric acids.

Inhibitors are frequently used to minimize attack on the metal. Concentrations will vary from 5% to 50% by volume. Scale loosening may be performed by solutions of potassium permanganate and caustic soda or soda ash followed by pickling.

2.4.2 Stripping of metallic coatings

This operation is used to salvage parts which have been rejected as a result of the faulty application of a finish. Chemicals are chosen which will remove the coating quickly with a minimum attack on the basic metal. Reverse electric current is frequently used in conjunction with the desired chemical.

Typical stripping baths include:

- Hydrochloric or sulphuric acid;
- Sodium hydroxide and sodium carbonate;
- Phosphoric acid with triethanolamine;

Sodium cyanide and sodium hydroxide;
Nitric acid;
Phosphoric acid and chromic acid;
Nitric acid and hydrofluoric acid.

2.4.3 Phosphating

Phosphating is a process designed to change a relatively unstable metallic surface into a stable, absorptive, non-metallic surface. The surface will also be non-conductive, an important factor in reducing corrosion.

The industrial applications are:

1. To improve corrosion resistance under paint and to provide a superior bonding surface.
2. To improve metal forming capability such as in extrusions, and to provide a base for lubricants.
3. To improve greatly the corrosion resistance of metals by providing a base for waxes and oils.

The basic chemicals used are zinc and iron phosphates with phosphoric acid. Manganese phosphates are occasionally used for extreme conditions. Concentrations vary from 5-10% by volume.

2.4.4 Chromating

Chromating is used on certain metals to produce a coating that is corrosion resistant, a good base for painting, or a decorative finish.

The bath is always acidic, containing hexavalent chromium compounds such as chromic acid plus organic or inorganic compounds which serve as activators or catalysts.

The pH of the baths will range from less than 1 to 3.

As the dissolved metal and trivalent chromium contamination increases it is periodically necessary under present technology to dispose of the bath. Frequency of disposal is influenced by the attention given to bath control.

2.4.5 Electroless plating

Immersion plating is the simplest form of electroless plating and the best known application is tinning. A typical solution would be

$\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$, 2 oz/gal; NaOH , 2.5 oz/gal; and NaCN , 1.0 oz/gal operated at boiling temperature.

A great variety of household utensils are treated with this process and it is widely used industrially.

Electroless plating may also take place by chemical reduction or auto-catalytic reduction.

The latter process is now widely used in depositing a metal layer on plastic so that the part may be subsequently electroplated. Of the metals that may be deposited this way the largest application is with copper and nickel.

In addition, copper is used as a deposit on circuit boards, and nickel on moulds or dies. In the latter case nickel imparts hardness, natural lubricity and anti-galling characteristics.

In the application of either copper or nickel as the substrate in the plating of plastics, a pre-plate procedure is required. This process includes the application of strong etchants, such as chromic acid, acid neutralisers, catalysts and accelerators.

The catalyst will most likely be palladium chloride and the accelerator a stannous chloride solution.

The copper plating bath will probably be an alkaline copper nitrate with formaldehyde as a major component.

The nickel bath will be nickel chloride with a hypophosphite and a glycollate and it will be strongly acid.

2.4.6 Bright dipping

Bright dipping is a special application of pickling, performed on aluminum, cadmium, copper, steel, zinc and stainless steel. Because of the vigorous chemical action of pickling and bright dipping, a heavy metal load accumulates in the baths and periodic disposal is required.

Mild acid baths with a concentration of 5% or less are used for light etching to improve adhesion of coatings and for surface activation.

2.4.7 Metal colouring

A wide variety of colouring effects are obtained on metals by using dips, e.g., antiquing and the blueing of gun barrels.

Most of the antiquing effects are obtained from alkaline sulphide solutions and thiosulphates. One formula for gun blueing contains copper sulphate, mercuric chloride, ferric chloride, nitric acid and denatured alcohol.

If present in any quantity in an effluent the sulphides may interfere with waste treatment.

2.5 Electrolytic Processes

2.5.1 Electrocleaning

Electrocleaning is a process used as a final preparation of parts after heavy soil has been removed by any of the cleaning processes mentioned above. The operation takes place in a heavy duty alkaline solution and the work may be anodic, cathodic or alternating between each condition. As in all the electrochemical processes that will be described the electrical source will be direct current at relatively low voltages and high amperages.

The function of electrocleaning is to remove remaining soil and to make the surface chemically active.

2.5.2 Anodizing

Anodizing is a process used to produce an oxide on a metal in a controlled manner. Its purpose is to give the base metal a corrosion resistant surface with some capability for resisting abrasion. It will also present a surface capable of accepting other finishes and, particularly in the case of aluminum, for accepting dyes.

While some limited anodizing is performed on zinc, by far the greatest amount is done on aluminum.

For alloys of aluminum with less than 5% copper the operation will take place in a chromic acid solution and for those with more than 5% copper it will take place in sulphuric acid.

A typical chromic acid bath will have 7-13 oz/gal of chromic acid with some chloride and sulphate ions present.

A sulphuric acid bath will have 15-20% sulphuric acid. Again the work is anodic and the anodizing may be followed by a sealing bath containing 6 oz/gallon sodium dichromate.

A typical process sequence for anodizing might be: vapour or alkaline soak degreasing - electroclean - acid dip - electropolish - or chemical polish - anodise and seal; with appropriate rinsing between each stage.

The chemical polish will be 85% phosphoric and 15% nitric acid.

2.5.3 Electroplating

Electroplating is the electro-deposition of an adherent metallic coating upon an electrode, which is the workpiece, for the purpose of obtaining a surface with properties or dimensions different from those of the basic metal.

These properties may include improvement of appearance, corrosion protection, wear resistance, etc.

The operation takes place in aqueous solutions containing the metal ion to be plated. The work piece is cathodic and in most instances the metal ion is constantly replenished from an anode containing the metal. A notable exception is chromium where the anode is insoluble and metal ions are replenished by additions of chromic acid.

Electroplating must be preceded by cleaning and activating operations and a typical sequence would be:

- a) Vapour degrease or soak clean in a emulsion or detergent cleaner
- b) Spray clean in a detergent cleaner
- c) Electroclean in an alkaline cleaner
- d) Sulphuric acid dip
- e) Electroplate
- f) Electroclean
- g) Sulphuric acid dip
- h) Second electroplate

Rinsing would follow each process stage except (a).

There may be a single electroplate only and it may or may not be followed by a chemical dip such as sodium dichromate or an oxidising agent.

The former would be most likely on zinc or cadmium and the latter on copper or brass.

Additional layers of electroplate may also be applied. For example in the plating of zinc diecastings, two layers of copper, and one or two layers of nickel and chromium are applied.

Typical acid plating baths are shown below in Table 1.

TABLE 1. TYPICAL ACID PLATING BATHS.

	Chromium	Copper 1	Nickel	Copper 2	Zinc 1	Zinc 2	Tin
Chromic Acid	25						
Sulphuric Acid	0.20	8					7
Metal Sulphate		28	44		24		5.5
Metal Chloride			6			18	
Copper Flouborate				45			
Boric Acid			5				
Phenol Sulphonic Acid							5.5
Sodium Acetate					6		
Aluminum Chloride						3	
Sodium Chloride						31	
Brightener		organic	organic				
Temperature	110-120F	ROOM	115-140F	65-120F	80-120F	ROOM	

(concentrations expressed in oz/gal)

The following notes apply to acid plating baths:

- 1) The above chromic acid bath would contain traces of fluoride and some baths may be operated with up to 53 oz/gallon chromic acid.
- 2) Black chromium is finding increasing application for non-reflecting surfaces and for this acetic acid is used in a 1:1 ratio with chromic acid.
- 3) Hard chromium plating differs from decorative plating only in the thickness of the plate. In order to impart this hardness over softer metals the thickness must be over 0.0015 inches.
- 4) Acid copper plating is finding increasing use as new developments improving levelling action make it useful in plating unbuffed plastic and other parts
- 5) The brighteners used in nickel plating impart the appearance characteristics and grain structure of the deposit. While low in concentration, their organic nature may interfere with a waste treatment or recovery system.
- 6) Nickel is also plated from a sulphamate bath where control of internal stress and fatigue is important.

- 7) Nickel plating is one of the most widely used and is most often found as part of a multi-layer system. It has the combined characteristics of hardness, appearance and corrosion resistance.
- 8) Zinc plated from cyanide baths has a better appearance than that plated from acid baths, but the acid bath is cheaper to operate. Sulphate baths are used to plate on malleable iron and strip steel. Chloride and alkaline baths are now on the market. They give a good appearance and are being offered as substitutes for cyanide zinc plating.
- 9) Tin plating from acid baths finds its main application in strip and wire plating. These operations are rather rare in Canada.

Typical cyanide plating baths are shown in Table 2.

TABLE 2. CYANIDE PLATING BATHS

	Zinc	Low CN Zinc	Cadmium	Copper 1	Copper 2	Gold	High Speed Silver	Tin
Metal Cyanide	10	1.75		3.5	10	2g/l	10	
Cadmium Oxide			3.0					
Sodium Hydroxide	15.5	12	1.9	0.5	4		Potassium 0.4	
Pot Hydroxide								3
Rochelle Salt				6				
Sodium Carbonate			4.0-10.0				Potassium 2	
Pot. Stannate								56
Tin Metal								21
Polysulphide			0.12					
Sodium Cyanide	5	0.50	10.5	4.6	12.4	Pot. 1	Potassium 12	
Brighteners	Org./ Met.	Org./ Met.	Org./ Met.	Organic	Organic	Dipot. Phos.2		
Temperature	Room	Room	Room	140F	140F	150F	100-120F	180F

(concentrations expressed in oz/gal)

The following notes apply to cyanide plating baths:

- 1) Zinc plating from cyanide baths is one of the most used plating operations in Canada. While it is primarily used for corrosion

protection, post-plating treatments can produce a decorative appearance.

- 2) Low cyanide baths require more care in operation.
- 3) Cadmium, while more expensive than zinc is used where superior corrosion protection is required. Improvements in the corrosion resistance of zinc and the use of chemical treatment systems has, in some cases, made cadmium plating unnecessary, since equivalent corrosion protection can be provided.
- 4) Cadmium has not leant itself readily to low cyanide formulations.
- 5) Copper plating from cyanide baths is always used in plating zinc diecastings.
- 6) The two formulations of copper, (1) and (2) above, are frequently found in successive baths with no rinse between.
- 7) Brass plating is a mixture of zinc and copper solutions. Cyanide levels tend to be higher.
- 8) Gold's application as a decorative plate is well known and the formulation shown is for this type. Industrial uses are increasing rapidly and production line techniques are being introduced.
- 9) Silver is also finding increasing industrial application in the electronics field.

Zinc is also plated from alkaline non-cyanide baths. This process has not widely replaced the traditional cyanide baths because of the greater difficulty in cleaning, especially in older facilities.

Copper is plated from pyrophosphate baths as a substitute for the higher concentration cyanide copper bath.

2.5.4 Electropolishing

This process, which is the reverse of plating, removes metal from the working surface. The effect is to smooth and brighten the surface and in some applications it is used for deburring.

Baths contain a variety of chemicals, depending on the metal being polished and the desired effect.

The bath may contain any of the following chemicals:

- 1) Fluoboric acid (Alzac process on aluminum)
- 2) Sulphuric and hydrofluoric acid
- 3) Phosphoric acid
- 4) Chromic acid
- 5) Arsenic acid
- 6) Tri-sodium phosphate
- 7) Ammonium phosphate
- 8) Nickel sulphate
- 9) Hydrochloric acid and glycerine

2.5.5 Electrocoating

Electrocoating or electrophoresis is a process in which an organic coating is deposited electrolytically. When D.C. current is applied in a bath where the work is cathodic there is a migration of pigment and resin particles to the part.

The excess paint is washed from the surface of the part as in other chemical treatments.

Paints used will include 8-10% solids, surfactants and possibly organic solvents.

The pH will be between 7 and 10.

2.5.6 Electroforming

Electroforming is a process using plating solutions to deposit a layer of metal of such thickness as to have structural strength of its own. It is used for paint masks and other applications where a configuration must be closely followed.

2.6 Wastewater Constituents

Table 3 shows the principal chemical constituents and concentrations found in untreated effluents from major metal finishing processes. Metal concentrations shown are mainly based on practical experience and/or information gathered during the survey of the metal finishing industry described in Section 3 of this report. The literature (1) confirms some of the values shown.

TABLE 3. PRINCIPAL CONSTITUENTS AND CONCENTRATIONS IN MAJOR METAL FINISHING PROCESSES, UNTREATED EFFLUENTS

Constituent	Plating on Steel	Plating on Zinc Casting	Plating on Brass	Plating on Plastic	Anodising	Concentrations
						mg/l
Fe^{+2}	x					1-10
Cu^{+2}	x (1)	x	x	x		5-50
Ni^{+2}	x	x	x	x	x	2-15
Cr^{+6}	x	x	x	x	x	10-120
Cr^{+3}	x	x	x	x	x	0.1-1.0
Zn^{+2}	x (2)	x				10-50
Cd^{+2}	x (3)					10-50
Sn^{+2}	x (4)			x		0.1-20
CN^{-1}	x (5)	x	x			1-50
SO_4^{-1}	x	x	x	x	x	15-25
Cl^{-1}	x	x	x			1-250
CO_3^{-2}	x	x	x	x		10-50
Si_3^{-2}	x	x	x	x		30-50
PO_4^{-3}	x	x	x		x	20-50
Organics	x	x	x	x		0.1-1.0

Note 1) When copper plating is used.

2) When zinc or brass plating is used.

3) When cadmium plating is used.

4) When tin plating is used.

5) When copper, zinc, brass or cadmium plating are used.

Figure 1 shows a typical flow sheet of a copper-nickel, chrome plating system. Water entering and leaving the system is shown to indicate where contaminated wastewater originates.

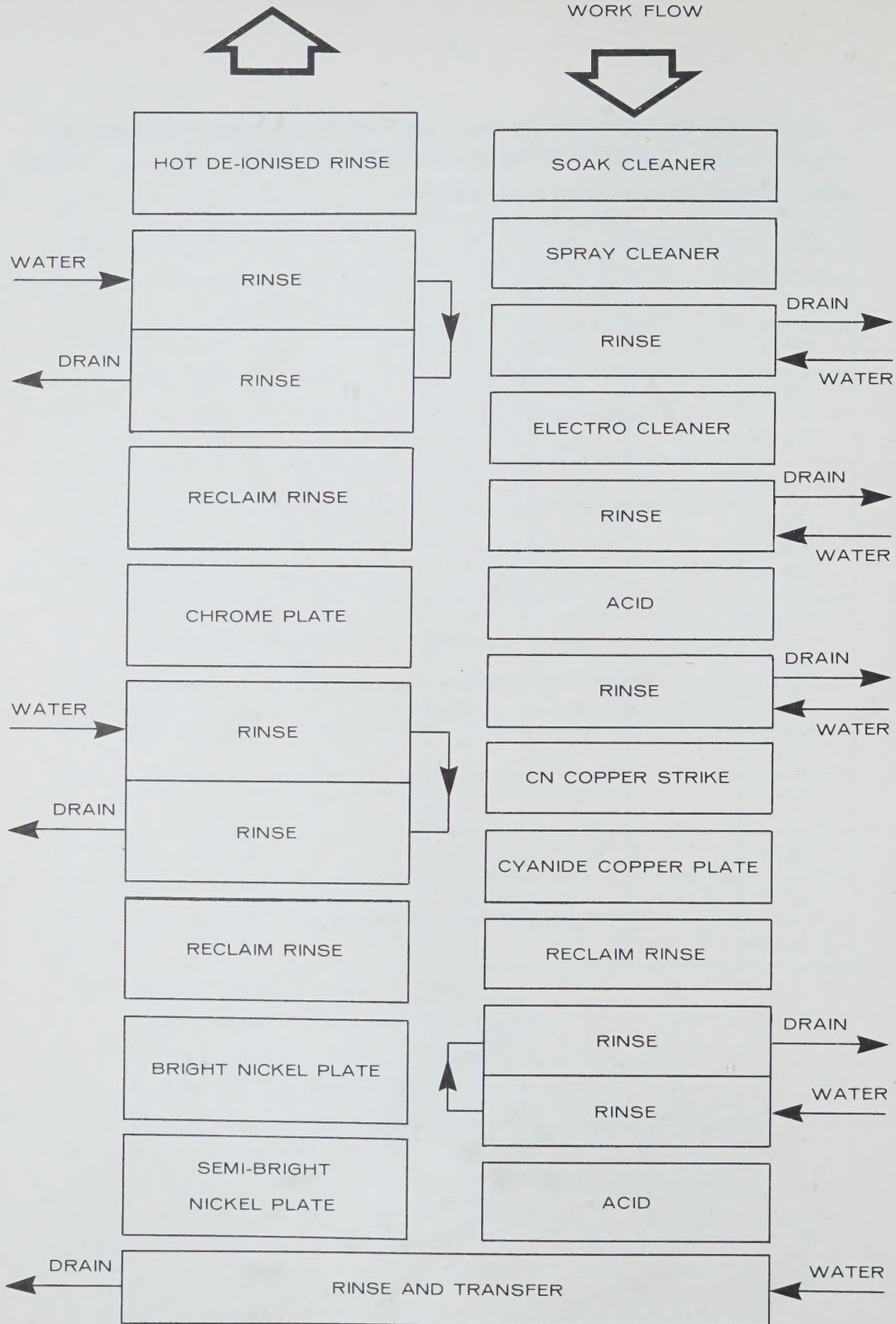


Figure 1. Schematic Flow Sheet of a Copper-Nickel-Chrome Plating System Without Waste Treatment

3. SURVEY OF THE METAL FINISHING INDUSTRY

3.1 Purpose and Method

The purpose of the survey was:

- 1) To identify companies in Canada with similar effluents.
- 2) To determine their size and geographic locations.
- 3) To identify the final destination of the effluents discharged.
- 4) To obtain approximate quantities of contaminants in the effluents.
- 5) To identify to what degree:
 - a. Internal control is exercised on waste.
 - b. External control is exercised on waste.
 - c. Recovery of chemicals is practiced.
 - d. Systems are similar.
 - e. Monitoring of effluent takes place.
- 6) To identify:
 - a. What chemicals are being used.
 - b. If any pollution control authority is aware of them.
 - c. Methods of disposal of concentrated dumps and sludges.
- 7) Where possible, to identify the flow rates and concentrations of toxic materials in the effluent.

The method used was a questionnaire consisting of four pages (see Appendix A) and for the most part the information was sought in a form that merely required a box to be ticked. Details of layout were requested only in schematic form and quantities required reference only to annual purchase records. Details of concentration of contaminants in the effluent were not expected to be available from all companies. Analyses were expected from those companies which had already had tests made. The accompanying letter requested response in 45 days. In practice a greater time was allowed and either telephone or personal follow-up was carried out on a selective basis. The survey was considered to be complete on February 15, 1974.

Selection of companies was made by reference to various trade listings and the personal knowledge of the consultant, regional offices of EPS and the Ontario Ministry of the Environment. The companies surveyed included not only those that were totally engaged in the specific processes under study but also those that used these processes as only part of a much

larger operation. These latter were harder to identify and the majority of replies indicating non-applicability were expected to occur within this category.

The questionnaires were sent to companies believed to be using these main categories of processes:

- 1) Electroplating
- 2) Anodising
- 3) Cyanide hardening
- 4) Electroless plating
- 5) Phosphating
- 6) Chromating
- 7) Acid Bright dipping

Over a thousand questionnaires were distributed and it was felt that very few companies were missed in the first four categories of processes above.

While the companies were asked to indicate if they had painting processes there was no attempt to include all companies with painting. Although the title of the survey indicates that the whole of the metal fabricating industry was to be surveyed, only that portion of the metal fabricating industry that had metal finishing processes with similar effluents was identified and surveyed. The companies using these processes were broken down into three principal divisions:

- a) Jobbers, who sell the services of these processes only;
- b) Captive operators, for whom the metal finishing operation is only a part of a much bigger operation;
- c) A group of companies that combine 1 & 2 in that they sell the total out-put of their plant on a jobbing basis but the metal finishing is only a part of that service. Most of the metal finishing in the automotive parts industry is in this category.

Metal finishing operations which are part of larger industrial activities such as steel production, foundry operations etc., were not included in the survey. Effluents requirements for such activities will take into consideration the metal finishing component.

3.2 The Questionnaire

The questionnaire was divided into seven main sections:

Section A, designed to indicate:

- 1) Size of company;
- 2) Relationship in numbers between employees on metal finishing operations and the total number of employees;
- 3) Length of time in metal finishing; and,
- 4) Contacts with pollution control authorities.

Section B, designed to indicate:

- 1) Broad areas of process; and
- 2) Receiving water body.

Section C, designed to indicate the various process categories in use as follows:

- 1) Mechanical;
- 2) Physical;
- 3) Non-metallic;
- 4) Chemical;
- 5) Electrolytic; and,
- 6) Layout of the processes in 4 & 5.

Since the first three process categories do not usually result in a large discharge of toxic materials in water effluents, the request for information was confined to indicating their existence only. Chemical processes in conjunction with these categories were to be picked up under categories 4 & 5.

In view of the difficulty of characterizing the effluents from the various plants, each company was requested to indicate, from its purchasing records, the type and quantity of main chemicals used in its surface treating processes.

3.3 Results

Over six hundred responses to the questionnaire, were received many of them solicited by telephone.

Replies from companies using mechanical, physical or non-metallic processes only were considered not applicable to the survey.

The applicable and tabulated replies were 341, and the information provided was analysed and, in several cases, modified or completed after contacting the company. A summary of the questionnaires sent and replies received is shown in Table 4.

A significant amount of general information gathered from the 341 tabulated questionnaires is summarized in Tables A.1 to A.11 and A.14 in Appendix A.

Data were compiled, arbitrarily, into two groups. One group contains companies with processes shown in Sections C.1, C.2, C.3, C.4 of the questionnaire, with the exception of cyanide hardening.

The second group contains all the companies which had cyanide hardening and/or any process in sections C.1, C.2, C.3, C.4 and C.5 of the questionnaire

When a company had processes in both C.4 and C.5 it was listed in the second group.

For the purpose of regulations development, it was of interest to identify the type and quantity of chemicals discharged with wastewater by the segment of the Canadian metal finishing industry which will be covered by the regulations.

To this end, an effort was made to:

- a) identify and quantify secondary chemicals normally used in conjunction with the main compounds specified; and,
- b) correct the quantities of all chemicals used to take into consideration companies which were sent the questionnaire but did not reply to it.

For each process in sections C.4 and C.5 a list of secondary chemicals was drawn from the knowledge of the baths used.

The companies which did not reply to the survey were considered and, if it was probable that they would be subject to the new regulations, process information and production or consumption figures were obtained or estimated. Correction factors were determined for each province. (See Table 5.) These correction factors were applied to all chemicals including secondary compounds, shown in the 341 tabulated responses. The results are shown in Table A.13 and all other tables derived from it.

TABLE 4. SUMMARY OF QUESTIONNAIRES SENT AND REPLIES RECEIVED.

EPS REGIONAL OFFICES

	Province					TOTAL
	Atlantic	Quebec	Ontario	Central	Pacific	
Provinces covered	Newfound-land Nova Scotia New Bruns- wick	Quebec	Ontario	Manitoba Saskatchewan Alberta	British Columbia	
Questionnaires mailed	15	272	572	165	64	1088
Replies received	9 (60)	150 (55)	311 (54)	88 (53)	51 (80)	609
Applicable	4	62	217	28	30	341

Table A.12 shows an assessment of the types and quantities of chemicals consumed by the segment of the Canadian metal finishing industry covered by the survey. A significant amount of these chemicals ultimately appear in the industry's wastewaters. In order to estimate the potential discharges from each process operation, an attempt will be made to develop multipliers that will indicate the probable quantities being discharged with rinse waters, dumps, spills, etc.

Another source of contaminants in the final effluent is the metal anodes. It has been estimated that 7 to 8 percent of the metal consumption is lost with the rinse water. Table A.16 gives an appreciation of the total metal consumption for the companies covered by the survey.

For the purpose of developing regulations Tables A.12, A.13 and A.16 are considered an adequate background.

TABLE 5. CORRECTION FACTORS

QUEBEC	1.6
ONTARIO	1.2
MANITOBA	1.4
ALBERTA	1.1

4. WATER POLLUTION PREVENTION

The probability and even the possibility that water pollution prevention can be carried out in the Canadian metal finishing industry must be considered realistically. As indicated by the survey discussed in Section 3 there is a wide disparity in the industry's awareness of its own operating details.

All of the proposals made in this section are within the capabilities of every metal finisher but his ability or willingness to devote the time to accomplish the improvements may be limited.

Advice has been available to him without cost from most popular trade publications, seminars of the American Electroplaters Society and from plating and waste treatment equipment suppliers for many years. The savings available are, however, often unknown to him because he is not aware of what his chemical losses are in relationship to what they could be. This is not only true of small shop operators but also captive plating operations within rather large companies.

All of the methods proposed in this section have a savings feature and most require an investment in time more than in facility. Some or all procedures are in use in some Canadian plants.

4.1 Substitution

The widest application of substitution has been the replacement of cyanide in zinc plating baths. One of these replacement baths uses a chelate to keep the zinc in solution but this presents a problem in precipitating the zinc in waste treatment. Zinc sulphate baths have been in use for some time in limited operations and new bright chloride baths have been introduced but are slow in gaining acceptance.

The slow acceptance of non-cyanide zinc baths can be attributed to traditional operations which depend on the cleaning action of the zinc cyanide plating tank to make up for inadequate cleaning earlier in the cycle. Chloride baths require that all plating tanks be acid resistant and capital cost would be incurred to make a change.

The result is that the widest substitution has been replacing high concentration cyanide baths with low concentration ones. Reductions of 90% in Cn concentrations are possible. Again tighter process control

requirements tend to deter many from making the change. There is a cadmium, cyanide-free bath on the market. Pyrophosphate is used as a substitute for cyanide in copper baths but may cause a problem in waste treatment when metals in mixed effluents are precipitated together.

Another form of substitution would be that of jobbing out work that required only the occasional use of a process that might be the only source of a particular pollutant. An example might be cadmium plating where there is no other cyanide plating in the plant. Other substitutes could be:

- a) Non-phosphate cleaners;
- b) Non-chromium dips (for conversion coating); and,
- c) Non-cyanide stripping solutions.

Not all salesmen of plating chemicals are aware of the pollution potential of their product. New products should be checked out carefully. Substitutes might cause as much trouble as they claim to avoid.

4.2 Water Use

There are many sewage treatment facilities that are hydraulically overloaded and the authorities must limit flow or direct an industrial effluent to storm sewers. It is usually better for the metal finisher to reduce his water flow and stay on sanitary sewers. When waste treatment is being considered the reduction to the lowest possible flow drastically reduces the cost of facility.

Where no previous control has been exercised it is easy to reduce flow for rinsing by 50% and possible to reduce it by 90%. The purpose of rinsing is to give good adhesion of each coating, to minimize residual films and to minimize contamination of subsequent baths.

The philosophy here is to get the most rinsing for the least water and this is influenced by the time the part is in contact with the water, how much uncontaminated water can be brought in contact in a given time, the temperature of the part and the water, and the shape of the part and its position on the plating rack. In actual practice the workpiece need not be perfectly rinsed.

Attacking the Problem

- 1) Identify the worst parts for dragout.
- 2) Run tests on this part using worst baths (Chrome or Cyanide).
- 3) Establish volume of dragout, and water flow.
- 4) Progressively reduce water flow until rinsing is inadequate (Operator co-operation essential).
- 5) Insert flow restrictor valves at a rate just above minimum acceptable.

If a single running rinse is being used, the addition of a second rinse with the water overflowing from it to the first tank will produce equivalent rinsing with 10% as much water. Spray rinsing will add mechanical action as well as delivering fresh water directly to the part. It is in operation only while the work piece is in front of the spray.

Fog rinsing is most useful when employed while the work is still over the plating tank. There must be some evaporation from the tank to permit the addition of water to it. This method is particularly effective since the chemicals are washed directly back to the tank. The rate of flow of the rinse may be controlled to equal the rate of evaporation.

Chemicals may be used as rinsing aids, such as in chrome plating where sodium metabisulphite in the rinse tank reduces the hexavalent chromium. This makes subsequent rinsing more effective and simultaneously provides some assistance to waste treatment.

The use of water from other sources, such as cooling water, will reduce the total load on a sewer system. When reducing water flow to rinsing, many aids are available to maintain the quality of rinsing. These include:

- a) Agitation of work while in the rinse tank,
- b) Air agitation of the rinse water,
- c) Hydraulic agitation of the rinse water,
- d) Mechanical agitation of the rinse water with mixers or impellers,
- e) Ultrasonic agitation of the rinse water,
- f) Raising of rinse water temperature,
- g) Wetting agents.

4.3 Control of Accidental Dumps and Leaks

Most existing plating installations in Canada permit spillage and overflows to the floor where they find their way to the lowest nearby drain. Acid leaks over a period of years can erode a flooring to the point where cracks and holes in the floor may permit leaks to pass through the building foundations and be absorbed in the adjacent ground.

A leak that may drop a tank depth two inches a day can go unnoticed for months with evaporation or drag-out being blamed for the losses. Similarly leaks in hoses, filters, heat exchanges etc., may occur in hard to get at places or simply be tolerated. Frequently, a tank being filled from a hose or a tap is left untended while two or three inches of solution overflow.

Steam coils and heat exchanger tubes may corrode with time and either take up solution or dilute to the point of overflow. Storage of chemicals may be in an area that can be flooded in a rain storm.

While it is relatively easy to make provision for all of these in a new installation it is very difficult in an old plant. Installation of acid proof floors and curbing to trap any leaks requires moving out the entire facility and taking it out of production unless alternate space is available. It is possible, however, to reduce the hazards in the following ways:

1. Fit all hoses used for adding water to tanks with spring loaded nozzles.
2. Curb the filter pump area. It will quickly show up leaks and the quantity involved and permit recovery of the lost solution.
3. Remove or seal all valves at the bottom of tanks containing process solutions and strong acids or alkalis. Transfer solution by pump rather than using such valves.
4. Take an occasional look at steam condensation. The process solution can ruin the boiler.
5. A tank or lagoon can often be inserted between the plating plant and the discharge to the sewer. Alarms can be set

up to warn of a sudden change in effluent. These alarms may also be used to shut off water supply. Even though some solution may escape to the sewer there will be some dilution from the tank or lagoon and a considerable amount of solution may be recovered.

6. Install siphon breakers on all water inlets.
7. Install a main shut-off valve on plating room outfall.
8. Initiate an effective preventive maintenance program on all tankage, heating and cooling coils, pumping equipment etc.

4.4 Drag-out and Drainage

The volume of solution carried from the process tank by the workpiece and its carrier is influenced by:

- 1) the speed of withdrawal;
- 2) the shape of the part;
- 3) drainage time;
- 4) viscosity and density of the solution;
- 5) temperature of the solution; and,
- 6) position of work on the rack.

The speed of withdrawal is least controllable in manual operation, followed by a manually operated hoist, and the best control is an automatic hoist system. Barrels will create the greatest drag-out problem but this can be helped by having the barrel rotating as it is withdrawn. In manual operations the rack can be hung over the process tank while the preceding rack is carried through its next operations. When the time of withdrawal and transfer is fixed the greatest possible time should be used for withdrawal.

The shape of the part and its position on the rack present a continuous compromise for the plater. Parts should not be racked one above the other but the limitations of electrochemistry and the economics of the operation usually make this a necessity. In extreme cases, however, the cost of waste treatment may dictate the reduction of pieces per rack to reduce drag-out. Use of a wetting agent will assist drainage

as long as it does not interfere in any other way. Drainage trays that catch drainage during transfer are a simple and direct recovery.

4.5 Reclamation

When all possible has been done to minimize drag-out losses, attention turns to reclamation of solution which is still on the work-piece and its rack. As mentioned in Section 4.2, fog spraying of parts while still over the process tank, where possible, will reclaim a great deal of solution. Failing this, or in addition to it, a reclaim tank immediately following the process tank will recover most of the solution that has been withdrawn. This tank would be a non-running water rinse which could be used as make-up for evaporation or other losses to the process tank before any water is added.

This procedure will increase the rate at which impurities build up and the ability to take advantage of it is related to the control maintained by supervision. Other potential reclamation sources are treatment tanks used to regenerate process solutions and sludges from filters when they are repacked. Various techniques are used by good operators but they all amount to washing down the cake or sludges and with adequate filtering returning the washings to the process tank. There is usually enough evaporation to permit substantial reclamation.

4.6 Regeneration

Regeneration techniques are commonly practiced by the industry as a means of extending the life of a plating solution almost indefinitely by removing metallic and organic impurities and carbonates. This was shown quite clearly by the survey. Solution losses can be kept quite small if care is taken.

A notable exception is chromic acid. When metallic impurities become intolerable a method frequently used is to remove a third of the solution and add fresh chromic acid. This would not be considered a dump by most companies in the survey.

Regeneration of chromic acid may be possible in the future with electrodialysis.

Most chemical treatments do become depleted and are dumped. Their life can be extended by as much as 50% with the use of inhibitors.

4.7 Solution Concentration

It is the custom of most metal finishers to operate baths in the middle of the recommended range of concentration. Because this range is fairly wide, many inefficient shops are in operation. Large savings are possible if baths are operated at the lower range of the concentrations permitted, and pollution levels would also be reduced.

A company operating in the middle range of nickel sulphate and nickel chloride using 8500 lb of the former and 2000 lb of the latter per year could save \$800.00 per year by operating at the lower range. This represents a saving of 1000 lb of nickel sulphate and 350 lb of nickel chloride per year which would not have been added to the bath. It also means that this quantity of nickel salts will not have entered the effluent.

4.8 Supervision

As stated in the introduction to this section, these water pollution prevention procedures all produce savings for the metal finisher but at this time there is little awareness of these potential savings or else the industry does not consider these procedures worthwhile. All of them require some additional degree of supervision from management down. The industry lacks personnel at the supervisory level with a broad enough knowledge to grasp the advantages available.

A rapid expansion in the industry in 1966 - 1968 found the industry unable to produce the necessary additional skills. Just as some training was taking place, an industry recession set in which carried through until 1972. It is only in the last year that training in any numbers has started again. There is a minority in the industry which believes that training should be kept to a minimum in order to keep labour costs down.

There are some captive operations where supervision is given to personnel who happen to be in a neighbouring, usually unrelated, department.

This lack of skills applies to the majority of individual companies but adequate skills do exist in the larger companies that make up the greatest dollar volume of the industry.

5. IN-PLANT WATER POLLUTION CONTROL

5.1 Water Uses

The function of water rinse in metal finishing is to remove from the surface of the workpiece dissolved and adhering materials that might be carried from one bath to another or which would stain the surface of the finished product.

Water rinsing is used after alkaline cleaners, acid pickling, and etching, and after each process bath that has a subsequent non-compatible process operation. It is also used to dilute dumps and to wash down floors.

Calculations from rinsing theory which are available from the literature, or empirical studies in-plant, will permit a determination of the minimum water required for the type of product and process used. This procedure, however, has been rarely followed in Canada since there has been very little incentive to conserve water. It is cheap and readily available in almost all parts of Canada and there is only occasionally a sewerage charge applied. A further encouragement to over-use water may occur when mild pressure for maintaining an effluent load measured in ppm is applied by authorities. A maximum use of water under these circumstances may bring effluent levels low enough to ease this pressure by simple dilution.

When companies are installing plating facilities, they rarely consider the cost of water in sizing their rinsing inlets and as a result they are frequently oversized. The operator usually has the control and he likes the safety factor that he believes this gives him.

The water required to rinse adequately is probably in the order of 1-2 gallons per square foot of work processed for each of the rinsing stations. When the amount of rinsing is determined either by calculation or empirically it can be controlled by using flow restricting valves, and conductivity controls with automatic shut-offs when no work is running.

If successive rinses are necessary to perform the rinsing function, counterflow rinsing will reduce the water requirement by 90% for each stage of counterflow rinsing introduced.

Once pollution control becomes necessary, there is a direct relationship between the size of treatment plant required and rinse water flow. It is at this point that most platers begin to consider water conservation seriously.

5.2 Stream Separation

Many metal finishing installations, including some large ones, do not separate individual rinse streams but simply overflow tanks onto the floor where all rinses mix and enter floor drains.

While this system simplified the original installation, it becomes a serious problem when attempting to treat the combined effluent. The nature of chemical treatment is such that stream separation is essential in order to permit the chemical reactions to take place within reasonable time.

In a plating system containing cyanide and chromium, at least three stream separations are required. A chromium stream is necessary in order to permit a reduction of hexavalent chromium to tri-valent form. A cyanide stream is necessary to permit oxidation of the cyanide with a minimum amount of complexing of the cyanide ion with metals, particularly nickel. After treatment, these streams may be combined with the remaining rinse waters for pH adjustment and precipitation of metals.

If recovery of any metals is desired, further stream separation into those containing the recoverable components becomes necessary.

A separation of flows from dumps of strong chemicals is also necessary so that these materials may be delivered to holding tanks where they may be batch treated or slowly added to the appropriate rinse stream prior to entering the treatment system.

A further separation of casual spills or leaks is necessary and this is accomplished by curbing the floor area under the tank or providing an emergency tank underneath, of the same volume as the process tanks, to retain an accidental flow.

Most of these operations are relatively easy in a new installation and are handled by a manifold system of piping the running rinses, eliminating valves on the bottom of process tanks, and curbing areas under process tanks and around pumps so that accidents or washings are either held or directed to the appropriate treatment system.

Established plants using simple floor drains present a much more difficult problem and considerable resistance is met by authorities who try to correct the problem. The greatest resistance occurs when it is necessary to shut down a plant to move tanks in order to take corrective measures with the floor. When this is done, however, it will often be found that acid has eaten through the flooring and that much of the rinse water is not going to the drainage system, but is being absorbed in the ground under and around the factory.

A floor properly installed, with curbing an integral part of it, will provide a safety factor against all but the most rare circumstance of the accidental loss of a tank larger than can be contained completely within the curbing. By far the most frequent accident will be a slow leak (which will be noticed by the accumulation inside the curbing) or the overflow of a process tank when make-up water is added.

Running rinses can always be picked up without disturbing production by piping the overflows. It may mean replacement of some rinse tanks but this does not constitute a major expense.

Ion exchange units are on the market which will cope with mixed rinses and act as concentrators so that treatment may be carried out on a batch basis. While this may present a solution where other alternatives are not available it will be expensive to operate and presents no opportunity for recovery of any chemicals. It does permit recirculation of rinse water, however.

A more sophisticated stream separation will permit recovery of specific chemicals and water. These are discussed more fully in the following sections. Even though recovery may not be economically feasible at the time of installation attention should be given to the future possibility because of changing values of metals and chemicals and improved methods of recovery.

5.3 Water Re-Use

As stated in Section 5.1, there is little incentive for metal finishers to spend money to minimize water use in Canada. There has, however, a great deal of incentive in other parts of the world. In England the combined cost of water and sewerage charges has become a

major economic factor in determining waste treatment design. In some instances it is the controlling factor.

A result of this emphasis has been an increase in the installation of more complex systems including reverse osmosis, ion exchange, controlled recirculation and integrated systems. Industry in England feels that the equipment manufacturers on whom they have usually relied for new developments are somewhat tardy and are undertaking some of this work themselves.

Water re-use sources in a plant include cooling water used in compressors, welders and heat exchangers, which is largely unchanged by its passage through equipment. There may be a small pick-up of metals which would not otherwise enter the treatment stream and may show up at measureable levels. Caution must be taken to see that any leak in a heat exchanger does not lead to contamination of the process. There are many installations in Canada where no effort has been made to take advantage of these sources of water, especially in captive plants.

Water re-use from the process itself is made possible when sufficient of the impurities are removed by treatment to allow the water to be re-used for rinsing. These treatments include ion exchange, reverse osmosis, evaporators, controlled recirculation of chemically treated rinse water, and integrated systems.

The controlled recirculation process (5) is very common in England but rarely used in North America. It uses the theory that since most of the contaminating salts have been removed by the treatment system the quality of the water permits its re-use in the same rinse tanks from which it came. Because there is an inevitable build-up of treatment chemicals a percentage of the rinse is continuously bled off to maintain a balanced load of dissolved treatment chemicals below the level that would be unacceptable in the rinse tank. For single rinse systems the recovery can be 50-70% and for double counterflow rinse systems from 60-80%. Returning water is passed through a sand filter which reduces total metals to 3.0 or mg/l or less.

The integrated system uses a minimum of two rinsing stages after the process bath. The first is a chemical rinse and the second has a partial recirculation of the water. This process will be described in more detail in Section 6.

The water from an ion exchange treatment system is usually of very high quality and can be returned to the rinsing cycle. There are physical changes that may have to be made to accept this water. Because of its chemically active nature, it will rapidly corrode unprotected welded steel tanks. Corrosion resistant tanks must be used or caustic soda added to raise the pH. The latter method is used only where it is impractical to replace tanks. As the ion exchanger approaches the need for regeneration the impurity levels rise in the recovered water and it would not be used for make-up water in process tanks.

Reverse osmosis is approximately 90% effective in separating contaminants from water so again the purified water may be re-used for rinsing. As with ion exchange there should be a warning system to indicate any failure causing a bleed of a contaminant.

Condensate water from evaporator recovery systems is also re-useable but is confined to rather low rinse flows. This requires a minimum of three counter-flow rinses and in some cases as many as six. When this is accomplished a closed loop system is possible.

Ion exchange, reverse osmosis and evaporator recovery systems are not usually installed as purely water-saving operations; the water saved is a by-product. Exceptions occur when a sewerage system cannot accept additional hydraulic load, regulations require a near zero discharge, or water sources become depleted.

5.4 Recovery of Chemicals and Metals

5.4.1 Chemical recovery

The economic factor determining the success of a chemical recovery system is the availability of a ready market for material as it is recovered by the metal finisher.

Thus in England and the continent it is possible to sell nickel carbonate and copper hydroxide, and ferrous sulphate at prices that recover some of the cost of operating the treatment system. An integrated treatment system that precipitates nickel as the carbonate and copper as the oxide finds occasional markets for the chemicals in North America. On some occasions the installation of an integrated

system has included an arrangement for exchanging nickel carbonate sludge for nickel sulphate. More encouragement in this direction as a result of higher metal salt prices may make these rather low concentration and impure sludges more interesting to the chemical industry.

5.4.2 Ion exchange

Ion exchange, demineralization and de-ionization are terms used interchangeably in the metal finishing industry to describe the process by which dissociated ions are absorbed on a prepared resin bed. The cation bed is permanently negatively charged and attracts cations such as sodium, calcium, aluminum, copper, cadmium and tri-valent chromium. The anion bed will attract negatively charged ions such as chlorides, carbonates, nitrates and chromates.

Its application for water purification is well known in the industry. Until recent years it was used principally to produce very high quality water (less than 2 mg/l dissolved solids) for final rinsing of parts and for make-up water in process tanks.

More recently it has been used to purify plating baths, concentrate rinse waters, to remove impurities before evaporation applications, as a concentrator to permit batch treatment of rinse waters and for the recovery of plating chemicals. A by-product of all of these is high quality rinse water recirculation.

Chromium plating baths build up with nickel, zinc, iron and tri-valent chromium impurities which cannot be removed chemically. Greater emphasis on good drainage and reclamation will increase the rate at which the bath approaches an inoperative status. These contaminants may be removed by diluting the bath to 12 oz/gal and passing it through a cation exchanger to remove these metals. If the quantity is large it may be necessary to evaporate sufficient water to bring the concentration up to bath levels before returning it to the process.

There are not many installations where exchangers are used as concentrators before evaporation, but cation exchangers are used as purifiers for rinses before concentration in the evaporator and for solutions being returned to the process from scrubbers.

There have been some recent installations in Ontario (6) where ion exchange has been used as a concentrator so that the effluent can be treated on a batch rather than continuous basis. Ion exchange will permit rinse water to be concentrated to about one-tenth its volume; rinses can, therefore, be reduced from 15000 gallons per eight hour shift to 1500 gallons. Since cyanides are destructive to these systems, these installations are used only where there is no cyanide or the cyanide stream is dealt with separately.

Since it is obvious that there must be a limit to the ability of the resins to absorb ions a rejuvenation is periodically necessary. This is a relatively simple process and can be made automatic. The anion resin is regenerated by passing through a solution of 5-10% sodium hydroxide and the cation resin by passing through 2-10% solution of sulphuric acid.

Nickel recovery is possible provided the rinse waters are sufficiently concentrated by counterflow rinsing techniques. The regenerant will be either nickel chloride or nickel sulphate depending on whether hydrochloric acid or sulphuric acid is used as the regenerator.

Gold, silver, and platinum may be recovered as metallic complexes from special resins which are incinerated to regain the metal.

While ion exchange is usually done with two separate columns of cation and anion resins, single columns of mixed beds may find some application. Single columns introduce some special problems, especially in regeneration and are usually confined to water purification.

A continuous ion exchange unit used in other industries has been applied to phosphoric acid recovery in one United States finishing plant. Small amounts of the resins are continuously removed from the column, regenerated and then returned. This uninterrupted flow avoids the necessity of duplication of units so that one will always be on stream.

For recovery purposes only, an initial capital installation at a cost of \$12,000, saving 15,000 pounds of nickel sulphate will pay for itself in $2\frac{1}{2}$ years. This does not take into account the cost of resin replacement, a somewhat unknown factor at present.

A recent development (7) uses relatively short columns and regenerates at frequent intervals. The regenerant from the anion is passed through another cation exchanger to recover chromic acid at about

10 oz/gallon concentration. A claim is made of cost recovery in 1 year, on a saving of 30,000 pounds of chromic acid per year plus chemicals for treatment. Capital cost would be about \$21,000.

The exchanger is installed in parallel to the most concentrated rinse tank and maintains the chromic acid level low enough to keep final effluent levels below the level of current enforcement standards. Duplication of equipment is unnecessary since the regeneration time is short enough that concentration of chromic acid in the rinse does not build-up to levels that will be objectionable in the final effluent.

Some question is raised as to whether the short columns of resin will permit channeling and so bleed-through of chromic acid.

In some operations it may be necessary to evaporate the chromic acid regenerant to be able to return it to the plating bath.

There are six such installations in Canada in medium sized plating plants.

5.4.3 Evaporators

Evaporators have been in use in the metal finishing industry for many years, in the larger plating plants for recovery of chromium, nickel and cyanides. The minimum initial capital cost and steam requirements prevent their economic use in smaller plants but where applicable have recovered their initial investment in a rather short time.

As with all recovery systems where the chemicals are returned to the bath there is a build up of impurities and these are usually removed by filtration and/or ion exchange.

It is possible to form a closed loop system in which the chemicals are continuously returned to the bath and the condensate returned to the rinse tanks. Figure 2 shows a layout for this type of system. This arrangement is limited by the small volume of condensation that is produced by the most practically sized units (8). The most frequently chosen size produces 200 gph. To rinse adequately with this volume requires at least three counterflowing rinses and sometimes as many as six. Where this cannot be used an open loop system may be installed but the rate at which investment is recovered is less.

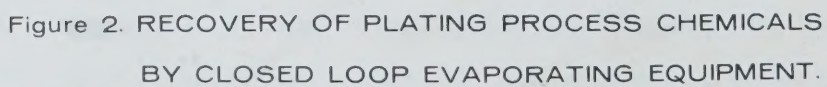


Figure 2. RECOVERY OF PLATING PROCESS CHEMICALS
BY CLOSED LOOP EVAPORATING EQUIPMENT.

The use of a vacuum permits the recovery of cyanides which might otherwise be destroyed by high temperatures.

A further limitation on the use of evaporators is the technological requirements of operating personnel. A separate unit is required for each type of chemical being recovered. A typical installation will cost \$80,000 plus. Single, double, and multiple effect evaporators are in use in the industry with choice often limited by sophistication of personnel.

There are over a hundred units in use in the United States and at least five in Canada.

Atmospheric evaporators are sometimes used to recovery chromic acid from scrubber units. The chromic acid is passed through a cation ion exchange unit before concentration, in order to remove metallic impurities that would otherwise build-up.

5.4.4 Reverse osmosis

Reverse osmosis accomplishes much the same result as distillation in that it separates an effluent into a concentrated solution of the dragged-out chemicals and nearly pure water.

The process reverses the normal osmotic pressures by applying a considerably greater pressure to the concentrated solution, thus forcing the water into the diluted solution, leaving behind most of the dissolved salts.

This is accomplished by creating a pressure differential across a membrane using pumps producing 400 - 800 PSIG. Maintenance problems are normally associated with such pumps. The present limitations for use in metal finishing are largely related to the membranes. Work at the Ontario Research Foundation has indicated the practical use of cellulose acetate membranes on nickel plating solutions but that membranes are not yet sufficiently developed to handle chromic acid or cyanide solutions.

Most of the work on reverse osmosis has been done in recent years (less than 10) and there are only a few installations in operation. Industry sees the applications of this method as very hopeful. Increasing effort is being made in the United States and Europe to improve the quality of membranes, develop new ones and simplify production units.

The ability to concentrate dilute solutions and return water suitable for rinsing makes this equipment a likely component of future installations required to meet more stringent discharge regulations.

Cellulose acetate is the membrane most commonly used and its use limited to pH ranges between 2.5 and 7. Temperature limits are between 65 and 90 degrees F. and it will not resist strong oxidizing agents. Further practical parameters are flow rates not exceeding 5 GPM and preferably around 2 GPM; no oil or heavy particles; and, rinse water only.

Other membranes being studied include polypropylene, polyurethane, and polyamides. These latter are being used for cyanide recovery since they can handle pH up to 12.

At the moment the cost of both cyanide and chromium units, combined with the many operating difficulties to be overcome, put this application far in the future for Canadian plating plants. There are perhaps 20 installations recovering nickel in the United States some of these being multi-unit.

It is estimated that where 18,000 lb of nickel sulphate is lost per year, the combined savings of the salt and associated brighteners and treatment chemicals will pay for a \$15,000 unit in two years.

The performance of these units still leaves 5 - 10 mg/l contaminant in the permeate for every 100 mg/l in the rinse water and so they must be primarily considered as recovery units rather than complete treatment units.

Since each of the three most likely types of equipment for recovery (evaporators, ion exchangers, and reverse osmosis units) have their limitations it is possible that combinations of them would permit a company to maximize the advantages while minimizing the disadvantages.

Closed loop requirements will certainly employ these systems in the next few years and one of the probable combinations will use reverse osmosis to remove the bulk of the contaminant with recovery possibilities, followed by ion exchange to remove the remainder. The backwash of the ion exchanger would be treated.

5.4.5 Electrolytic recovery of metals

This method, which would seem to have obvious merit for the electroplating industry has found only limited application. The advantage of using equipment familiar to the industry and with a low operating cost is unfortunately offset by the inefficiency at low levels of concentration. Units which have been designed for cyanide destruction may also be used for metal recovery, but have encountered practical problems in the limited number of installations which exist.

A newer approach developed in Canada, and now in use (9) for cyanide destruction in the cyanide hardening applications where dump concentrations are high, may have application at the lower levels of concentration of plating effluents. If it does prove successful it will work on the principle of a plating cell in parallel with a rinse tank of the highest possible concentration of metal salts that can be practically achieved.

This approach, but not this process is presently in use in the United States for the recovery of gold and silver.

Another application is used by large brass and copper tube manufacturers to recovery metal from the bright dipping operation. The bright dip solution is sulphuric acid and hydrogen peroxide and the most concentrated rinse is continuously circulated through an electrolytic cell.

In most instances where electrolytic recovery is used it is still necessary to treat the effluent for the remaining metal.

5.5 Concentrated Dumps

Concentrated dumps are undoubtedly more dangerous than all of the nuisance polluting that occurs from running rinses. Their potential for shock loading a stream or sewerage treatment system is the greatest damage the metal finishing industry in Canada offers to sewerage treatment systems and streams in Canada. At the same time its avoidance is simple. It is an operation that is initiated by a man under orders.

Materials most frequently dumped are cleaners, acids, both dilute and concentrate, conversion dips that become spent, and chromating and colouring compounds. The make-up and concentrations of many of these

dumps were described in Section 3. There is, in addition, some metallic content in many of these dumps. Alkaline cleaners may contain hexavalent chromium which has stripped off plating racks. Acid bright dipping of copper and zinc will produce concentrations in excess of 1000 mg/l of metal. Chromic acid cleaners used in plating on plastics may contain 40 oz/l gal (250 gm/l) of chromic acid when spent. Pickling baths for removing heavy scale on steel parts are often found in metal finishing departments and will be heavily loaded with iron.

Many operators consider that disposal down a drain with some flushing with a hose is a sufficient waste treatment and their ability to pick the time of such dumping makes it difficult to detect this practice. There is ample evidence, however, of the effect on a municipal waste treatment facility in Canada since many have been put out of action at least temporarily by such dumps.

The remedy, in contrast to treating running rinses, is relatively simple. If there is an overall treatment system, tanks can be provided to accept these dumps and their contents can be slowly added to the treatment system over the period of time between dumps. But it may also be simply dealt with by itself. It is usually sufficient to provide one tank for alkali dumps and one for acid. They may then be chemically batch treated, allowed to settle and the clear water decanted. The remaining sludge may then be removed by a sludge disposal tanker at relatively low cost. *where to?*

Sludges from vapour degreasers and paint strippers should be disposed of separately and emulsion cleaners may have to be acidified to break up the emulsion before treatment, thus requiring a separate dump tank.

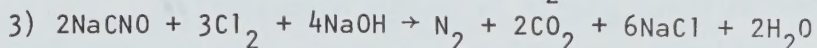
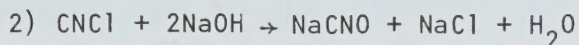
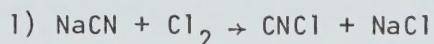
6. EXTERNAL CONTROLS

6.1 Cyanide Destruction

6.1.1 Oxidation by alkaline chlorination

By far the most universally used system for the destruction of cyanide is that using chlorine gas or sodium hypochlorite in an alkaline solution.

The reaction is believed to take place in three steps:



The first reaction is almost instantaneous but the second reaction takes a minimum of 5 minutes at the optimum pH of 11.5 and much longer at a pH below 9.

The third reaction is longer again, about 30 minutes at its optimum pH of 8.5.

In practice it is wise to maintain a high pH during reaction (1) not only to speed the reaction, but also to eliminate any possibility of evolution of the toxic gas cyanogen chloride (CNCI).

While reaction (2) will still take place at a lower pH in additional time, reaction (3) will take an almost infinite time at a pH of 11.

The amount of chlorine required per pound of cyanide as CN is 4.25 to 4.5 pounds for the complete reaction through (3). If destruction to the cyanate form only is required, the chlorine demand would be about 1.25 pounds.

Additional quantities of chlorine will be required if there are any other oxidizable compounds present. A copper solution containing Rochelle salts will demand more chlorine as will any organic materials present.

The presence of nickel or iron, and to a lesser extent copper, will further complicate the reaction by forming complexes that take time to break down. These create so much difficulty that every effort is made to avoid or minimize their presence in the cyanide stream.

The consumption of sodium hydroxide for the complete reaction is approximately 4.25 pounds.

The selection of the specific chemicals to be used is dependent on local cost, availability, storage arrangements, control methods and personnel.

Chlorine gas is the cheapest source of chlorine in large quantity in most locations but presents hazards in storage and in use that some companies prefer not to cope with. Calcium hypochlorite is often preferred in batch treatments, but the most frequently used form in medium sized plants is sodium hypochlorite.

Similarly the choice of lime vs. caustic soda for pH control will be dictated by cost (lime is usually cheaper) versus a combination of factors including space, capital cost, and sludge disposal.

Since the first two reactions above are combined oxidation - reduction at a steady pH value it is possible to monitor the reaction by redox potential. This permits a determination of the reaction completion by a specific redox value measured in millivolts. It is then a relatively simple step to extend monitoring to control and, combined with pH monitoring and control, an automatic control of cyanide destruction is possible.

This automatic control may be applied in batch treatment or extended for use in a continuous flow, continuous treatment system.

A complete system for the destruction of cyanide to CO_2 and N_2 is designed in steps. The first stage will raise the pH to 11.5 (some plants operate at 10.5 balancing risk of incomplete reaction against lower cost) and chlorine will be added. The equipment is designed for a ten minute dwell time with vigorous mixing.

The second stage will lower the pH to 8.5 and additional chlorine will be added. A dwell time of thirty minutes is usually allowed, again with vigorous mixing. This pH is selected since it permits the precipitation of all the metals likely to be present and is acceptable in the final effluent.

It is dangerous to use alkaline chlorination for solutions with cyanide concentrations greater than 500 mg/l because of heat generation.

6.1.2 Electrolytic destruction

Electrolytic destruction has been used for some years to destroy cyanide in concentrated dumps. The cost can be as low as 5 cents per pound of cyanide destroyed and the equipment is often made up of surplus pieces of plating equipment. If there are metal ions present they will plate out or precipitate at the cathode. Recovery is a possibility where only one metal is involved. The method is limited by the loss of conductivity as the process proceeds and is virtually stopped at levels below 100 mg/l of cyanide so that the remaining cyanide must be chemically destroyed.

A proprietary electrolytic process that increases cathode area substantially using a carbon bed has encountered difficulty with blinding of the bed by metal hydroxides. Further development work has been done of this method but it has not yet reappeared on the market.

A related method has been introduced for the destruction of cyanide dumps from the metal hardening industry and some equipment has been introduced to the Canadian and American market. Its developers, a Canadian company (9), believe the process will have application in the electroplating industry but have not as yet introduced such equipment.

The use of electrolytic destruction for polysulphide-cyanide solutions is possible but more difficult than simple cyanide dumps. The tendency of the anodes to scale up requires periodic replacement or descaling.

6.1.3 Carbon adsorption and catalytic oxidation

A process has been introduced in the United States for catalytic oxidation of cyanide (10). The effluent is passed through a carbon absorption unit which provides the reactive surface. Copper chloride is introduced as a catalyst and oxygen is fed to the unit. The system received very limited acceptance, probably since it does not offer material advantage over existing chlorination systems.

Ozone will also oxidize to the cyanate form but again it does not appeal to the metal finishing industry at this time since there are

not any obvious advantages to the industry.

There have been some applications in Europe precipitating cyanide as the ferro-cyanide but the process has never been adopted in North America and new installations in Europe are ignoring it. There is some risk of a reversal of the reaction in sunlight.

6.1.4 Oxidation with formalin and hydrogen peroxide

A process that may have application in some circumstances has been on the market for a little over a year (11). It will convert the cyanide to the cyanate and precipitate the metal oxide from zinc and cadmium solutions. Work is being done to extend the application to copper solutions.

The active reagents are formalin and hydrogen peroxide. The process becomes proprietary by the addition of stabilizers and compounds which help the reaction and the settling of the precipitate.

This method lends itself to small plant applications where metal levels of 1-2 mg/l, and cyanate are acceptable in the final effluent.

It is a requirement that there be sufficient counterflow rinsing to achieve maximum levels of cyanide in the rinse water. While it is simpler to use this system in a batch treatment plant, continuous flow treatment is possible.

Claims of lower cost of equipment and operating chemicals would seem to be borne out by the reasonably large number of installations which have adopted the process in a short time.

Where quantities justify it, there is a possibility of recovery of the metals.

The key to the acceptance of this system, of course, is whether cyanate can be permitted in the final effluent. There has been much dodging of this issue and the simplest approach by authorities has been to require complete destruction of cyanide to CO_2 and N_2 . If destruction to the cyanate form can be accepted as sufficient for discharge to sanitary sewers in medium to large cities, this ruling would encompass the majority of smaller plating plants which will find it difficult to finance and run cyanide destruction systems.

6.2 Chromium Reduction and Removal

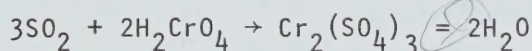
Most of the chromium in metal finishing plant effluents will be in the hexavalent form originating from rinses from chromium plating,

chromic acid cleaning and etching baths, or chromate bright dips. There will be, in addition, concentrated dumps from the cleaning, etching and bright dip baths.

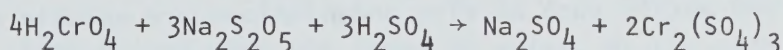
The most frequently used method for removing chromium from the discharge waters requires the reduction of hexa-valent chromium to the tri-valent state and subsequently precipitation, usually as the hydroxide.

The choice of reduction agent is dependent on cost, availability and convenience. The chemicals most frequently used are sulphur dioxide, sodium bisulphite, sodium metabisulphite and ferrous sulphate. The latter is most used when it is available as a by-product to sulphuric acid descaling within the same plant.

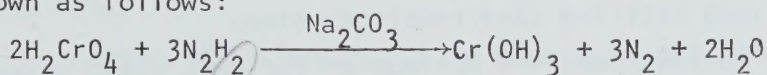
The chemical reactions involved can be shown as follows:



Using sodium metabisulphite with sulphuric acid the reaction is:



In one of the systems which will be discussed later, where treatment is in line with plating process, a second alkaline reduction is added using sodium hydrosulphite or hydrazine. This latter reaction may be shown as follows:



The acid reaction occurs very rapidly at a pH of 2-3. If the chromium bearing stream is separated from any alkaline streams it will have a pH close to 3 in most plants. When the pH must be lowered sulphuric acid is used.

As with cyanide destruction it is possible to make this a continuous treatment operation using redox control for the addition of the reducing chemicals and pH controllers for the pH adjustment.

When reduction is complete the trivalent chromium may be precipitated as the hydroxide by raising the pH to 8.5. If there are other metals present in the system their streams will be mixed with the chromium for this operation.

Claims of cost for the reduction and precipitation of chromic acid vary widely but are usually substantially higher than the theoretical cost. Claims have been made for costs as low as 24 cents per

pound excluding sludge disposal costs. However costs of or above 45 cents per pound of chromic acid destroyed appear to be more frequent.

6.3 Other Metals Removal

The final removal of all metals usually found in metal finishing operations is most frequently carried out by precipitation of the metal as the hydroxide.

The pH of acid solutions is raised toward neutrality and the pH of alkaline solutions is lowered.

Metal salts from simple inorganic compounds will tend to become insoluble in the neutral pH range, but not all metals will precipitate just on neutralization, and not all metals will precipitate at the same point and to the same extent.

Nickel will require a relatively high pH to reach minimum solubility and metals such as zinc and aluminum are soluble at alkaline pH's.

In addition the solubility of each metal is influenced by the presence of other ions and, in practice, the solubility of a metal after pH change and settling, for say one hour, may be different from the value after long settling (and reaction) time.

It follows that the optimum pH for each mixed stream depends on a combination of factors including the regulatory requirements for the concentration of a toxic metal in the final effluent.

While it has been generally indicated that a pH of 8 - 8.5 is usually selected it should be also stressed that such values are not necessarily the best for each individual mixed effluent under the specific legislative requirements.

Values currently found in literature do not normally elaborate on all the conditions under which the metals precipitation has been carried out but rather leave the reader with a list of final concentrations of metals after precipitation and separation. Occasionally the distinction between metals in solution and in suspended solids is made.

The Development Document for Effluents Limitations Guidelines and New Source Performance Standards for the Copper, Nickel Chromium, and Zinc segments of the Electroplating Point Source Category (see

reference 1) reported that 50% of 53 plating plants examined for regulatory purposes had values less than the following:

Cu	.2	mg/l
Ni	.5	mg/l
Cr ⁶⁺	.055	mg/l
Cr ^T	.3	mg/l
Zn	.3	mg/l
Cn oxidizable	.04	mg/l

and with the additional contribution of metals from suspended solids which are not completely removed from the effluents:

Cr _T	.55	mg/l
Cu	1.0	mg/l
Ni	.65	mg/l
Zn	1.3	mg/l

Such values were not found to exist, at the same time, in 50% of the plant effluents. They rather represent to which extent the technology applied by all plants under consideration has reduced the metals content in the final effluents. Not all plants had all the contaminants at the same time.

A greater variation occurs in metals in the suspended solids than in metals in solution, since techniques of settling and/or filtering of these solids is not as well developed as the chemical reactions.

The plants used to determine the figures quoted above are better run than the average plating facility. There are many plants which do not achieve results better than 5 mg/l at the best and will more than likely operate in the range of 5-15 mg/l.

The precipitation of the metal hydroxide begins immediately when the chemicals come into contact with the hydroxyl ion, but in order to insure that this occurs a dwell time of 10-15 minutes is allowed.

The operation may be handled on a batch, automatic batch, or continuous treatment basis. The latter two methods will use pH controllers for the hydroxide addition.

The hydroxide may be caustic soda or lime. Again the choice is based on the same considerations as were discussed under cyanide destruction.

Dumps containing high concentrations of metals will be sent to holding tanks with chromium preferably separated from the other metals. These dumps may then be batch treated or slowly fed to the main treatment system. Overloading of the treatment system is a frequent cause of large variations in effluent quality.

While the chemical reaction is very rapid the development of the size of the metal hydroxide particle is rather slow. As a result, additional time is needed to improve the ability of the metal hydroxide to be settled or filtered.

6.4 Liquid-Solid Separation

There are three major phases in successful waste treatment installations: chemical destruction; precipitation; and, liquid-solid separation. While the first is the most neglected, the last is the most difficult and expensive.

As a result, those companies which have installed treatment facilities have tried to avoid this last phase as long as possible, gradually leading up to it by steps. A typical pattern followed by many has been to:

- 1) Discharge precipitated solids to sewers;
- 2) Discharge to a lagoon when space is available;
- 3) Install a settling tank, or
- 4) Install an on-stream pressure filter;
- 5) Install a clarifier;
- 6) Add a filter or centrifuge to a settling tank or a clarifier.

Step (1) still occurs in Canada, especially in the larger cities, but it has these potential risks:

- a) The discharge will have 4-600 mg/l solids containing metal hydroxides primarily.
- b) Solids from burnishing operations may settle out and plug smaller sewers.
- c) Gelatinous floc, typical of metal hydroxides can coat the bed of an aerobic sewage treatment system in smaller systems.
- d) Incinerated sludge will discharge metal oxides through the exhaust stack.

- e) Sludges from sewage treatment plants are sometimes spread over farm lands as fertilizer and these lands will accumulate an increasing amount of metals.
- f) Metal hydroxides may resolubilize due to acidic conditions arising from decay of organic materials.
- g) The discharge may be a danger to bacteria used in sewage treatment process.

Discharge as in (2) to a lagoon is rarely used now for these reasons:

- a) A large amount of land is required.
- b) The lagoon walls may breach.
- c) While the soil may act as an ion exchanger and absorb soluble metal, it may also permit percolation and contamination of nearby water.
- d) Overflow of clears still contain 50-100 mg/l solids.
- e) As a lagoon fills, its efficiency decreases.
- f) It must eventually be desludged or closed.

When attention is paid to good design, a settling tank may be expected to produce an overflow with 30-50 mg/l solids and a sludge at the bottom with 1-2% solids content. Automated valve control for discharge of these solids can double the solids concentration of the sludge withdrawn by minimizing channeling which would permit nearly clear liquid to be discharged.

Settling tanks may be vertical and silo shaped or horizontal with baffling and a slant bottom.

If vertical, the height from the weir overflow to the beginning of the hopper bottom is approximately 14 feet. The hopper is at an angle of 60° from the horizontal. Feed is from the top through a centre tube which projects about 8 feet down into the tank.

If horizontal, the length is about four times the width and the feed is spread over the full width by a feed well.

The objective of both designs is to produce a laminar flow with a rest area for the accumulation of the sludge. Retention time is a minimum of four hours in both designs, once again emphasizing the necessity of minimizing flow rates.

Vertical units are more popular in Europe where they may be operated outside and are considered by industry there to be slightly more efficient and less complicated than horizontal tanks.

Clarifiers are more complicated and expensive than settling tanks but since a bottom scraper continuously removes sludge, the performance is more consistent. They are fitted with weirs, baffles and feed wells to give maximum chance for good settling. The clears will contain 15-30 mg/l solids and the sludge 2% solids.

The addition of tube or Lamella settlers to either of these tanks will double their rate of settling, permitting a small installation, but the clears and underflow will be approximately the same.

In most instances, using either type of basic settling system it is necessary to add coagulating chemicals, such as ferric chloride or aluminium sulphate, or high molecule polyelectrolytes.

The metal salts add a complication in that they increase the volume of sludge and the polyelectrolytes are expensive and must be carefully selected to suit the floc.

Calcium hydroxide is preferred for the precipitating agent since it aids settling although it also adds to the volume of the sludge.

Care must be taken to avoid high concentrations of wetting agents or cleaners containing silicates since they tend to suspend the floc. It is common practice to use the alkalinity in the cleaners to raise the pH of the final effluent but if settling is to be used to remove solids it may cause considerable difficulty in the settling tank.

As an alternative to clarifiers there have been many installations of on-stream pressure filtration units. They are more expensive than the simpler systems above but will produce a filtrate with 0-5 mg/l solids and a disposable cake with only 45-60% water. Cake removal can be made automatic.

They are, however, subject to some limitations as follows

- 1) There are limits to the choice of neutralizer.
- 2) Constant flow conditions must be maintained. A power failure for even a short time can cause the cake to be dropped on a vertical leaf filter.
- 3) Floc must be carefully prepared.

- 4) There is a variation in the filterability of various metal hydroxides.
- 5) Two units are usually required to maintain continuous operation.

Recent installations in Canada have avoided the use of on-stream filtration.

There are several installations in the United States and Europe that achieve sludge thickening by dewatering using porous materials that allow the passage of water without outside pressure application. One type uses a special porous concrete block and another a tank made of plastic that is permeable to water. The only block installations in Canada have been discontinued but there is one using the plastic tank. Solids concentrations of 10% are claimed.

Settling plus filtration is now, reluctantly because of cost, finding increased use since it combines the advantages of the above systems while largely eliminating the disadvantages.

Filters used include vacuum and pressure types. Vacuum filters require a feed stock of 2.5-5% solids. They are expensive and many planters hesitate to use them because they require close control. As a result they are usually found in only the largest plants.

Chamber filters will permit a larger cake and are again seen only in the large installations.

The most widely used filter is the plate and frame type. When fed the settled sludges, these filters will produce a filtrate that is too high in solids to be discharged and it is returned to the settling system. The cake will contain about 50% solids and this is a reasonable material for disposal.

A few installations outside of Canada have used centrifuges to perform the same function as the filter. The spin-off is returned to the clarifier and solids content of 15-20% can be achieved.

Metal hydroxides do not lend themselves readily to centrifugation and the equipment is unfamiliar to most of the metal finishing industry.

6.5 Oils, Grease and Cleaners

The major sources of these pollutants are cleaner dumps, running rinses used after cleaners, and cutting oils.

Most Canadian companies dispose of cutting and other machining oils by removal to municipal or other dumps since the quantities are not large.

Cleaner dumps are discharged to sewers, except where there are waste treatment installations.

These cleaners contain oils and greases removed from the work pieces, metallic soaps from the polishing operations and in some cases emulsion cleaners.

Because oil and grease removal were considered to be minor problems early waste treatment systems largely ignored this class of pollutants. However, their tendency to interfere with the operation of pH and redox sensors has made greater attention to their disposal necessary.

The simplest means of separating oils and greases is static settling and this will take care of most dump applications. Emulsions may have to be broken by lowering the pH and heating, followed by decanting and sludge disposal. Stubborn applications may require coagulating agents and other settling aids.

Running rinses, which will not usually contain large quantities of oil and grease, are most readily handled by one of a variety of skimming devices. Larger installations may use plate and/or tube separators which work on much the same principle as those in settling tanks described above.

If soluble oils such as cutting oils cannot be disposed of by dumping, it is then necessary to overcome their solubility. Simple acidification may be all that is required but in some instances alum and air flotation may be used.

Recovery of these oils is possible with a combination of separation and filtration but rare in this industry.

6.6 General Information

While each of the above treatment systems has been dealt with separately they are rarely found alone but rather in combinations of two or more systems. pH control seldom occurs alone but when it does it may be applied in the same manner as part of the control mechanism of any of the above.

The equipment required to make these systems operate may be designed for manual batch treatment, automated batch or automated continuous flow treatment or a combination of any of them.

The determination of the system to be used is dependent on the various cost factors of labour, materials, and space plus the skill and the knowledge of available personnel.

As a rough guide, batch systems are not practical when flows are above 3 GPM for each stream. This may be modified if a concentrator such as the ion exchange or reverse osmosis equipment described above is used.

Figure 3 illustrates a batch treatment system for cyanide destruction, chrome reduction, metal precipitation, settling and dewatering of the sludge. Cost estimates shown are $\pm 10\%$ and dependent on availability of good engineering and service.

Figure 4 illustrates an automated continuous treatment system and Figure 5 an integrated system with chemical rinsing. Figure 6 illustrates an ion exchange and batch treatment for nickel - chromium wastewater.

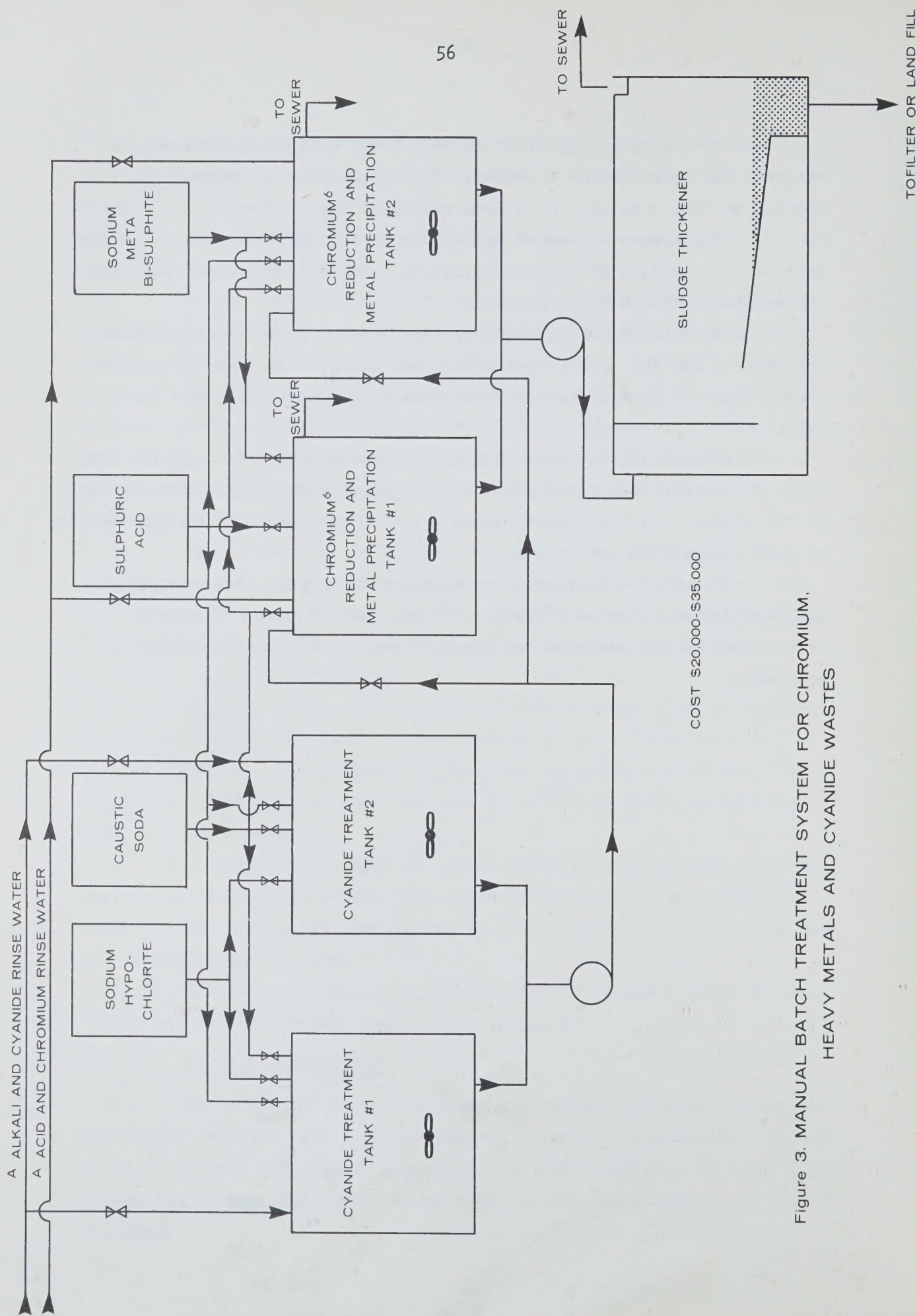
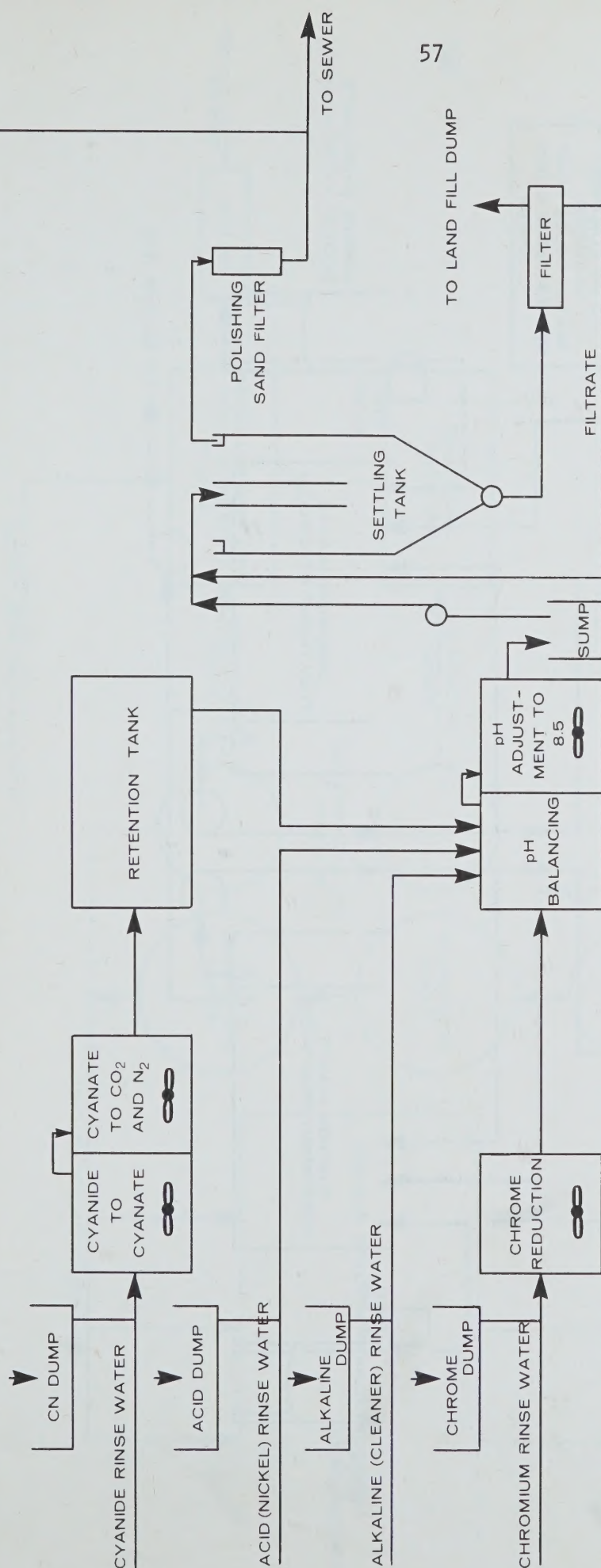


Figure 3. MANUAL BATCH TREATMENT SYSTEM FOR CHROMIUM,
HEAVY METALS AND CYANIDE WASTES

50% RETURN TO PROCESS RINSING

57



To avoid cluttering of the schematic diagram the various pH and redox controllers and probes have been omitted as have the chemical treatment tanks.

COST-APPROXIMATELY \$125,000

Figure 4. AUTOMATED CONTINUOUS FLOW TREATMENT FOR CHROMIUM, HEAVY METALS AND CYANIDE WASTE.

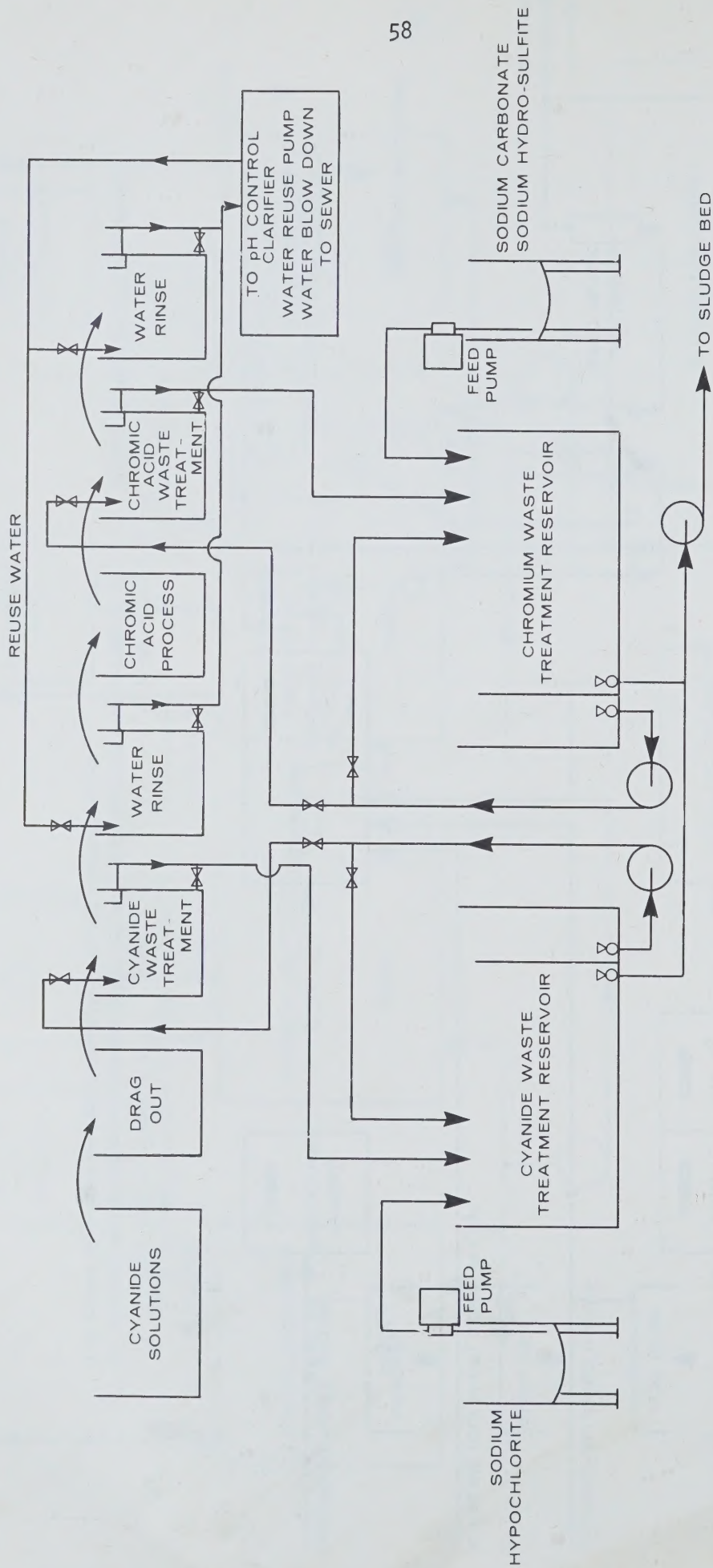


Figure 5. INTEGRATED TREATMENT SYSTEM

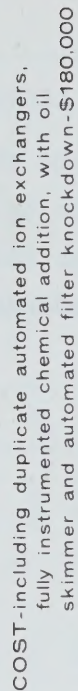


Figure 6. ION EXCHANGE AND BATCH TREATMENT FOR NICKEL-CHROMIUM WASTEWATER

7. EXISTING LEGISLATION

Table 6 and the accompanying notes provide information on the existing legislation or effluent requirements for metal finishing industries in the United States and other foreign countries. Tables 7 and 8 show some discharge standards used for metal finishing operations in England.

TABLE 6. FOREIGN LEGISLATION OR REQUIREMENTS FOR METAL FINISHING OPERATIONS.

	U.S.	FRANCE			ENGLAND*				GERMANY (21)			
	(1) (2)	(2) (4)	(8)	(10) (11)	(12) (16)	(17)	(19)	(22) (23)	(25)	(26)		
pH	6-9		5-9	6.5-8.5	6-9	3-10		6.5-9	6-8	6-9		
TSS	15 (3)				10-20	100	50					
oil & grease		5.0 (7)			5.0	50	25	10 (24)		10 (24)		
BOD	50				20 (13)	1000	10000					
CN (oxidizable)	0.05	0.1 (5)	0.1	0.02	1.0 (14)	10 (14)		0.1		0.1		
CN (total)	0.5				(14)	(14)						
Cd	0.1-0.4 (3)	1.0	3.0 (9)		(15)	(18)	(20)	3.0				
Cr ⁶⁺	0.05	0.1	0.1	0.02	(15)	(18)	(20)	0.5	0.5			
Cr (total)	0.5	(6)			(15)	(18)	(20)	2.0	2.0			
Cu	0.5	1.0	(9)	1.0	1.0	10	5.0	1.0				
Fe	1.0	0.5	(9)	<1.0	(15)	(18)	(20)	2.0				
Pb	0.5				1.0	10	5.0					
Ni	0.5	1.0	(9)		(15)	(18)	(20)	3.0				
Ag	0.05				(15)	(18)	(20)					
Sn	1.0 (3)				(15)	(18)	(20)					
Zn	0.5	1.0	(9)	5.0	1.0	10	5.0	3.0				
Al	0.5 (3)				(15)	(18)	(20)					
Phosphate	1.0 (3)											
Fluoride		15	15	1.0					20			
Nitrites											20	
Free Chlorine	5-15 (3)	1.0						0.5			0.5	
Ammonia (as NH)					1.0	5.0	50					

* All values expressed in mg/l

* All values, unless otherwise specified, are effluents standards

* Examples of actual requirements are appended. (See Table 7.)

NOTES TO TABLE 6

- (1) Values for wastewater constituents considered in reference (1).
- (2) Values include dissolved and undissolved solids.
- (3) Limit under discussion.
- (4) Achievable values in effluents wasted as follows:
 - a) CN destruction to N_2 and CO_2 .
 - b) Chrome reduction.
 - c) Precipitation of heavy metals at their optimum pH.
 - d) Evaporation of wastewater containing organics which can solubilise metals.
 - e) Nitrite reduction.
 - f) Precipitation of fluorides.
 - g) Settling of sludges.
 - h) Filtration of final effluent.
 - i) Absorption of organic material.
 - j) Final pH adjustment.
- (5) An additional limit for cyanates is also given: 0.1 mg/l
- (6) An additional limit for Cr^{3+} is also given: 1.0 mg/l.
- (7) Substances extractable with chloroform.
- (8) Effluents standards to achieve water quality values as in (10).
- (9) Total of zinc + cadmium + copper + iron + nickel.
- (10) Water quality values necessary to support life and reproduction of fish "normally" present in the river and/or necessary for the use of the river water as drinking water after simple or normal treatment.
- (11) Values under revision.
- (12) Conditions normally attached to consents for discharge to Inland Water Courses.
- (13) It includes COD.
- (14) It includes sulphides; distinction made between oxidizable and total CN.
- (15) Metals not specified are normally at 1.0 mg/l with a total maximum metal content of 2-3 mg/l.
- (16) In some instance effluents quality limits are not given but there is a general requirement that effluents shall not contain substances

in sufficient concentrations either separately or in combination as to be harmful to flora and/or fauna downstream from the point of discharge.

- (17) Conditions normally attached to consents for discharge to estuaries.
- (18) Metals not specified are normally at 10 mg/l with a total maximum metal content of 10-50 mg/l.
- (19) Conditions normally attached to consents for discharge to public sewers.
- (20) Metals not specified are normally at 5 mg/l with a total maximum metal content of 25 mg/l.
- (21) Federal "directives" specify that in order to permit a polluted body to return to a healthy state, the effluents discharged into it should as a rule, possess the maximum degree of purity attainable by normal treatment procedures.
- (22) Degree of purity attainable by galvanizing plants treating their effluents as it follows:
 - a) CN destruction
 - b) Chrome reduction
 - c) Precipitation and removal of metal salts
 - d) Neutralization
- (23) In special cases lower metal values can be obtained for individual metals by using secondary purification procedures.
- (24) Substances extractable with petroleum ether.
- (25) Degree of purity attainable by anodizing plants testing their effluents as it follows:
 - a) Neutralization
 - b) Settling and sludges removal
- (26) Degree of purity attainable by hardening shops treating their effluents as it follows:
 - a) CN destruction
 - b) Neutralization

TABLE 7. SOME ENGLISH RIVER AND LOCAL AUTHORITY DISCHARGE STANDARDS FOR METAL FINISHING OPERATIONS.

PARAMETER	SEVERN RIVER AUTHORITY	TRENT RIVER AUTHORITY	UPPER THAME MAIN DRAINAGE AUTHORITY	COVENTRY BOROUGH COUNCIL	GREATER LONDON COUNCIL MIDDLESEX REGION	WEST HERTFORDSHIRE MAIN DRAINAGE AUTHORITY
pH	6-9	5-9	6-12	6-10	6-10	6-10
Temperature	<20°C	<30°C	<105°F	<110°F	<110°F	<110°F
Settleable solids (mg/l)	<30	<30	<400	<500	<400	<500
Total toxic metals (excluding Fe and Al) in solution and in suspension as com- pounds, expressed as metals. (mg/l)	<0.5	<1	<30	<40 plus <40 zinc	<20 cadmium <15 chromium <20 copper <20 nickel <20 zinc <20 lead, etc.	<50 cadmium <20 chromium <50 copper <50 nickel <50 zinc <20 tin
Total toxic metals in solution, expressed as metals. (mg/l)	Not Specified	Not Specified	<10	(including <5 copper, <5 lead) plus <10 Zn	Not Specified	Not Specified
Cyanides (mg/l) - simple soluble - additional complex excluding ferro- cyanide	(as HCN) <0.1 <0.1	(as CN) <0.1 Not completely covered by test	(as CN) <10	(as HCN) <1 <1	<20	<20
- ferrocyanide	<0.3	Not Specified	Not Specified	<3		Not Specified
Phenols (mg/l)	<0.5	(monohydric) <1	-	-	Not Specified	<500
Sulphides (mg/l)	(as H ₂ S) <0.1	Not Specified	-	-	(as S) <1	(as S) <20
Sulphur dioxide (mg/l)	<200	Not Specified	Not Specified	-	<1	Not Specified
Free chlorine (mg/l)	<1	<1	Not Specified	-	<10	<100
Oil & grease (mg/l)	(petroleum ether extract) <4	<5	Nil	<100	<400	<400
BOD (mg/l)	<20	<20	<322	-	Not Specified	Not Specified
PV (mg/l)	-	<20	-	<200	Not Specified	Not Specified

TABLE 8. EXAMPLES OF CONSENTS TO DISCHARGE OF TOXIC METALS FROM METAL FINISHING OPERATIONS TO THE THAMES RIVER.

PLANT	EFFLUENT FLOW m ³ /d	TOXIC METALS mg/l	CN mg/l	CHROMATE (8) mg/l	Cr* mg/l	Cu mg/l	Zn mg/l	Ni mg/l	Cd mg/l	Pb mg/l
1	982	1.5	0.2	-	-	-	-	-	-	-
2	9	-	-	5.0	-	-	-	-	-	-
3	91	-	0.05	-	1.0	0.5	2.0	1.0	1.0	-
4	3410	-	-	5.0	-	-	-	-	-	-
5	23	-	0.1	-	3.0	0.2	4.0	-	-	3.0
6	682	0.5	None	-	-	-	-	-	-	-
7	1310	-	0.1	-	5.0	0.5	-	3.0	3.0	-
8	636	None	None	-	None	-	-	-	-	-
9**	Not Available	-	<0.1	-	<1.0	<1.0	<1.0	<1.0	<1.0	-

* as Cr

** other conditions pH 6.5-8.5; free chlorine 0.5 mg/l

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GLOSSARYAcid Dip

An acidic solution used to neutralize any alkaline solution adherent to a workpiece after alkaline cleaning and to activate the surface prior to plating.

Activation

The elimination of a passive condition on a surface.

Activator

A chemical solution used to precipitate metal from an electroless plating bath onto plastic.

Addition Agent

A material, usually organic added to a plating bath to modify the character of the deposit. Brighteners are in this category.

Alkalinity

The concentration of OH ions expressed as pH for a solution.

Ampere

The current which will deposit silver at the rate of 0.0011180 gram per second

Ampere-hours

Amperes of electricity multiplied by the time of use in hours.

Anion

An ion which is negatively charged.

Anode

The electrode at which current enters or electrons leave, the solution: the positive electrode in electrolysis.

Anodising

The anodic treatment of metals, especially aluminum, to form an oxide layer in a controlled manner.

Automatic Plating

A conveying system by which cathodes are carried through a complete cycle of plating automatically. Semi-automatic plating is a system by which cathodes are carried through only one tank automatically.

Barrel Finishing

Bulk processing of work in rotating barrels in the presence of abrasive particles.

Barrel Plating

Bulk electroplating of work pieces in a rotating container.

Basis Metal

Material upon which coatings are deposited.

BOD

Biological oxygen demand.

Bright Dip

A solution used to chemically brighten metal.

Brightener

An addition agent that causes the deposited metal to be bright.

Buffing

The smoothing of a surface using flexible wheels and fine abrasive compound in oil or grease.

Captive Operation

An electroplating system operated by a company which also makes the work pieces being processed.

Catalyst

As applied in electroless plating it is a chemical substance, usually palladium chloride, used to cause the electroless deposition of a metal onto plastic.

Cathode

The electrode at which current leaves or electrons enter the solution: the negative electrode in electrolysis.

Cation

An ion which is positively charged.

Chelate Compound

A compound in which the metal is contained as an integral part of a ring structure and is not readily ionised.

Chelating Agent

A compound capable of forming a chelate compound with a metal.

Chrome

Used somewhat loosely interchangeably with chromium.

Cleaner

A pretreatment operation prior to plating or other metal finishing for the removal of soil such as oils, greases and manufacturing compounds.

Closed Loop Evaporation

A system of recovering chemicals and rinse waters, returning them to the baths from which they came, in a closed loop.

Complexing Agent

A compound capable of forming a complex ion with a metal ion.

Continuous Treatment

A treatment system that continuously monitors and treats the effluent, as opposed to batch treatment.

Conversion Coating

A coating produced by chemical or electrochemical treatment of a metallic surface that gives a superficial layer containing a compound of the metal. e.g. chromate coatings on zinc and cadmium.

Current Density (cd)

Current per unit area.

Degreasing

The removal of grease and oils by solvent or vapour from a work piece.

Deposit

The material (metal) deposited on the base material.

Detergent

A surface active agent with the ability to clean soiled surfaces.

Deionisation

The removal of ions from a solution by ion exchange.

Deioniser

Some times used interchangeably with ion exchanger.

Drag-In

The water or solution carried into the bath on the work piece and rack.

Drag-Out

The water or solution carried out of the bath on the work piece and rack.

Dual Nickel Plate

A plating system in which two layers of nickel are deposited from different baths in order to impart a combination of improved corrosion resistance, bright appearance, and improved ductibility.

Effluent

The wastewater discharged from a point source to a receiving water or sewage system.

Electrode

A conducting material through which current enters or leaves an electrolytic cell.

Electrodeposition

The process by which a substance is deposited on an electrode by electrolysis.

Electroforming

The production or reproduction of articles by electrodeposition on a mandrel or mould that is subsequently separated partly or wholly from the deposit.

Electroless Plating

Deposition of a metallic coating by a controlled chemical reaction which is catalyzed by the metal being deposited.

Electrolysis

Production of chemical changes by the passage of current through an electrolyte.

Electrolytic Cell

A unit apparatus designed for carrying out an electrochemical reaction; includes a vessel, two or more electrodes, and an electrolyte.

Electrolytic Decomposition

An electrochemical treatment used for the oxidation of cyanides.

Electroplating

The electrodeposition of an adherent metallic coating upon an electrode for the purpose of securing a surface with properties or dimensions different from those of the basis metal.

Electrophoresis

The movement of colloidal particles produced the application of an electric potential.

Electropolishing

The improvement in surface finish of a metal effected by making it anodic in an appropriate solution.

Emulsion

A suspension of small droplets of one liquid in another in which it is insoluble.

Flocculate

To aggregate into small lumps; to increase in size to the point where precipitation occurs.

Free Cyanide

True. - the actual concentration of cyanide radical (or equivalent alkali cyanide) not combined in complex ions with metals in solution.

Calculated. - the concentration of cyanide (or alkali cyanide) present in a solution in excess of that calculated as necessary to form a specified complex ion with a metal (or metals) present in the solution.

Analytical. - the free cyanide content of a solution, as determined by a specified analytical method.

Galvanising

The application of a deposit of zinc, usually on steel or a ferrous metal.

Grinding

The removal of metal by means of rotating rigid wheels containing abrasive.

Hard Chromium

Chromium plated for engineering purposes rather than decorative applications. Not necessarily harder than the latter.

Immersion Plate

A metallic deposit produced by a displacement reaction in which one metal displaces another from solution.

Integrated Chemical Treatment

A waste treatment method in which a chemical rinse tank is inserted in the plating line between the process tank and the water rinse tank.

Ion Exchange (IX)

An exchange of ions usually between a solution and a solid. Used interchangeably with de-ionisation (DI).

Mandrel

A form used as a cathode in electroforming.

Nitriding

The formation of nitrides of metals by heat treating in special atmospheres.

ORP Recorders

Oxidation-Reduction potential recorders.

Oxidation

A reaction in which electrons are removed from a reactant. Sometimes, more specifically, the combination of the reactant with oxygen.

Oxidisable Cyanide

Cyanide amenable to oxidation by chlorine according to standard analytical practice.

pH

A unit for measuring acidity or alkalinity of water, based on hydrogen ion concentrations. A pH of 7 indicates neutral water or solution. A pH lower than seven indicates acidity and a pH higher than 7 indicates alkalinity.

Passivity

A condition of a metal such that it assumes a potential more noble than its standard potential. A condition in electroplating that will interfere with the adhesion of subsequent coats of plate.

Pickle

An acid solution used to remove oxides or other compounds related to the basis metal from the surface of the metal by chemical or electrochemical action.

Plated Area

The area of the workpiece receiving an electrodeposit.

Plating Barrel

The container in which parts are placed loosely, so they can tumble as the barrel rotates in the plating solution.

Plating Rack

The jig or fixture which carries the workpieces through the process tanks and carries the electrical current to the workpieces.

Polishing

The smoothing of the metal surface by means of abrasive particles attached by adhesive to the surface of wheels or belts.

Reclaim Rinses

Still rinses immediately following process tanks which are used to make up for evaporative or drag-out losses in the process tanks which immediately precede them.

Rectifier

A device which converts ac into dc by means of a characteristic permitting appreciable flow of current in only one direction.

Reducing Agent

A compound which causes reduction, thereby itself becoming oxidized.

Reduction

A chemical reaction in which electrons are added to the constitution of the reactant; the addition of hydrogen or the abstraction of oxygen. This reaction takes place at the cathode in hydrolysis.

Reverse Osmosis

A recovery process in which the more concentrated solution is put under pressure greater than the osmotic pressure to drive water across a membrane to the dilute stream while leaving behind the dissolved solids.

Rinse

The water of chemical solution used to remove dragged-out materials adhering to racks and workpieces as they come from the process tanks.

Running Rinse

A tank in which water is continually running in and out.

Still Rinse

A tank in which the water is not continuously replenished.

Soak Cleaning

Cleaning by immersion without the use of current.

Strike

Noun: A solution used to deposit an initial thin film of metal.

Noun: A thin initial film of metal to be followed by other coatings.

Verb: To plate for a short time.

Substrate

The basis metal.

Surface Active Agent - "Surfactant"

A soluble or colloidal substance having the property of affecting markedly the surface energy of solutions even when present in low concentrations.

Total Chromium

This is the sum of chromium in all valences, whether dissolved or in precipitated form.

Total Cyanide

The total content of cyanide expressed as the radical (CN) or alkali cyanide whether present as simple or complex ions. The sum of both the free and combined cyanide content of a solution.

Total Metal

The sum of all the metal content in both soluble and precipitated form.

Volt

The voltage which will produce a current of one ampere through the resistance of one ohm.

Watt

An energy rate of one joule per second, or the power of an electric current of one ampere with an intensity of one volt.

Wetting Agent

A substance which reduces the surface tension of a liquid thereby causing it to spread more readily on a solid surface.

Workpiece

The item being processed.

APPENDIX A

QUESTIONNAIRE AND TABULATION OF INFORMATION



Environment Canada
Environmental Protection

Environnement Canada
Protection de l'environnement

**SURVEY OF
THE METAL FABRICATING AND FINISHING INDUSTRY
OF CANADA**

FOR

**ENVIRONMENTAL PROTECTION SERVICE
WATER POLLUTION CONTROL DIRECTORATE
ABATEMENT AND COMPLIANCE BRANCH**

NAME OF COMPANY			
HEAD OFFICE ADDRESS		PLANT ADDRESS	
PLANT TEL. NO.	PERSON TO CONTACT	TITLE	TELEPHONE NO.

A COMPANY INFORMATION									
		METAL FABRICATING	METAL FINISHING		4. IS YOUR OPERATION KNOWN TO POLLUTION CONTROL AUTHORITIES? ☐ YES ☐ NO If "YES" specify which authority. FED. - ☐ YES ☐ NO PROV. - ☐ YES ☐ NO MUN. - ☐ YES ☐ NO				
1. NUMBER OF EMPLOYEES									
2. YEAR PRODUCTION STARTED									
3. TOTAL NUMBER OF EMPLOYEES IN COMPANY									
B GENERAL INFORMATION									
CHECK TYPE OF PROCESS USED	1. MECHANICAL Grinding, Sand Blasting etc.		2. PHYSICAL Hot Dipping, Spraying of Molten Metal		3. NON-METALLIC COATING Painting, Plastic Coating etc.		5. ELECTROLYTIC Electroplating, Anodizing, etc.		
	☐		☐		☐		☐		
6. INDICATE WHERE WASTE WATER FROM YOUR SYSTEM FLOWS				7. INDICATE WHERE SANITARY WATER FROM YOUR SYSTEM FLOWS					
A. TO MUN. SANITARY SEWER				B. TO MUN. STORM SEWER					
C. TO WATER		SEA WATER	LAKE WATER	STREAM	C. TO WATER		SEA WATER	LAKE WATER	STREAM
D. TO GROUND		TILE FIELD	DEEP WELL	SEEPAGE PIT	D. TO GROUND		TILE FIELD	DEEP WELL	SEEPAGE PIT

NOTE:

Continue with the questionnaire only if any of questions B-1 to B-5 are checked. If all questions from B-1 to B-5 were unchecked, it is not necessary to continue. Simply forward the questionnaire as indicated in the covering letter. Thank you.

FOR THE DIAGRAM REQUESTED BELOW, THE FOLLOWING ABBREVIATIONS ARE ACCEPTABLE.

R. = Rinse A = Acid E.C. = Electrolytic Cleaner
 REC. = Reclaim S.C. = Soak Cleaner C. = Cleaner

GLOSSARY:

imp. gal. = imperial gallons lb. yr. = pounds per year
 l.g./hr. = imperial gallons per hour p.p.m. = parts per million
 lb. = pound sq. ft. = square feet

C. PROCESS INFORMATION (Check process used)		
1. MECHANICAL	2. PHYSICAL	3. NON-METALLIC COATING
☐ Sand Blasting ☐ Tumbling ☐ Vibratory Finishing ☐ Polishing and Buffing ☐ Other (Specify) ☐ ☐ ☐	☐ Aluminum Coating ☐ Lead Coating ☐ Tin Coating ☐ Galvanizing ☐ Other (Specify) ☐ ☐ ☐	☐ Degreasing ☐ Cleaning ☐ Pickling ☐ Derusting ☐ Phosphating ☐ Chromating ☐ Painting (enamel, varnish, etc.) ☐ Other (Specify)

NOTE: Complete the table below, as applicable.

4. CHEMICAL		Products Processed per day		Maximum Yearly Capacity		No. of Process Tanks	Total Capacity of Tanks imp. gal.	Main Chemical In Process Tanks	No. Dumps per yr.	Consumption	
		sq. ft.	lb.	sq. ft.	lb.					Main Chem. lb./yr	Metal lb./yr
DE-GREASING	(i) VAPOR										
	(ii) EMULSION										
	(iii) DETERGENT										
PICKLING	(i)										
	(ii)										
DE-RUSTING											
STRIPPING METAL COATINGS											
PASSIVATING											
ACTIVATING											
PHOSPHATING											
CHROMATING											
ELECTROLESS COPPER PLATING											
ELECTROLESS NICKEL PLATING											
BRIGHT DIPPING											
HARDENING											
OTHER (Specify)											
5. ELECTROLYTIC											
DE-GREASING	(i) VAPOR										
	(ii) EMULSION										
	(iii) DETERGENT										
PICKLING											
ELECTROCLEANING											
ETCHING											
ANODIZING	(i) SULPHURIC										
	(ii) CHROMIC										
LEAD PLATING											
COPPER PLATING	(i) CYANIDE										
	(ii) ACID										
NICKEL PLATING	(i) BRIGHT										
	(ii) SEMI-BRIGHT										
CHROMIUM PLATING											
TIN PLATING											
ZINC PLATING	(i) CYANIDE										
	(ii) NON CYANIDE										
CADMIUM PLATING											
BRASS PLATING											
GOLD PLATING											
SILVER PLATING											
ELECTROPOLISHING											
OTHER (Specify)											

6. NOTE: In the space provided on page 2, please provide a schematic diagram of the layout of all the chemical and electrochemical processes, showing process and rinse tanks. Use additional sheets if necessary. Up to date drawings showing the above information would be acceptable.

D. WASTE WATER INFORMATION				E. SLUDGE DISPOSAL	
ESTIMATE OF TOTAL WATER CONSUMPTION OF PLANT		ESTIMATE VOLUME OF WATER USED FOR SANITARY SERVICES		DO DUMPS OF PROCESS BATHS RECEIVE IN-PLANT TREATMENT BEFORE DISPOSAL?	
APPROX. I.G./hr		APPROX. I.G./hr		☐ YES ☐ NO ☐ PLANNED	
GIVE AN ESTIMATE OF WASTE WATER CONTAINING ANY OF THE FOLLOWING, AS APPLICABLE.				DO YOU DISPOSE OF WASTES CONTAINING OIL?	
	I.G./hr	WITHOUT TREATMENT	AFTER TREATMENT	☐ YES ☐ NO ☐ PLANNED	
CYANIDE		ppm	ppm		
HEAVY METALS CHROMIUM, COPPER, ETC.		ppm	ppm	☐ YES ☐ NO ☐ PLANNED	
NITRITE		ppm	ppm		
PHOSPHATE		ppm	ppm		
OIL		ppm	ppm		
FINAL EFFLUENT		pH	pH	WHAT MEANS DO YOU USE FOR SHIPPING SPENT BATHS OR SLUDGES?	

F. WATER POLLUTION CONTROL MEASURES			G. MONITORING AND RECORDING																				
1.0 IN PLANT CONTROL MEASURES			2.0 EXTERNAL CONTROL MEASURES																				
1.1 ARE ANY OF THE RINSE STREAMS CONTAINING THE FOLLOWING, SEPARATELY PIPED?			2.1 DO YOU HAVE pH CONTROL OF WASTE WATER? ☐ YES ☐ NO ☐ PLANNED																				
☐ (a) Cyanide ☐ (e) Acid-Alkali ☐ (b) Nitrite ☐ (f) Cooling Water ☐ (c) Chromium ☐ (g) Concentrated Dumps ☐ (d) Oil			If "YES", complete the following																				
LIMITS		CHEMICALS USED	ANNUAL CONSUMPTION																				
			lb.																				
			lb.																				
1.2 INDICATE WHICH OF THE RINSE STREAMS OF F1.1 GO TO			2.2 DO YOU HAVE SOLIDS REMOVAL FROM WASTE WATER? ☐ YES ☐ NO ☐ PLANNED																				
DRAIN SYSTEM WITHOUT FURTHER TREATMENT	DRAIN SYSTEM WITH FURTHER TREATMENT	HOLDING TANK	If "YES", please check which method.																				
			☐ (a) Settling ☐ (c) Filtering ☐ (b) Flotation ☐ (d) Other (Specify)																				
1.3 DO YOU RECOVER CHEMICALS BY MEANS OF A RECLAIM TANK?			2.3 DO YOU HAVE A CYANIDE DESTRUCTION SYSTEM? ☐ YES ☐ NO ☐ PLANNED																				
☐ YES ☐ NO If "YES", please indicate such reclaim on the schematic diagram requested in C-6.			If "YES", check which method used.																				
1.4 DO YOU RECOVER CHEMICALS FROM YOUR RINSE WATER? ☐ YES ☐ NO ☐ PLANNED			BATCH MECH. AUTO AUTO CONTINUOUS (a) Oxidation with Hypochlorite or Chlorine ☐ ☐ ☐ (b) Destruction in Electrocleaner ☐ ☐ ☐ (c) Complexing with Iron Sulphate ☐ ☐ ☐ (d) Electrolytic Destruction ☐ ☐ ☐ (e) Other (Specify) ☐ ☐ ☐																				
If "YES", check which method			2.4 DO YOU HAVE A CHROMIUM TREATMENT REMOVAL SYSTEM? ☐ YES ☐ NO ☐ PLANNED																				
☐ (a) Chemical Recovery ☐ (c) Ion Exchange ☐ (b) Evaporation ☐ (d) Other (Specify)			If "YES", check which method used.																				
1.5 DO YOU RECOVER OR RECYCLE RINSE WATER? ☐ YES ☐ NO ☐ PLANNED			BATCH MECH. AUTO AUTO CONTINUOUS (a) Precipitation with Barium Salt ☐ ☐ ☐ (b) Reduction from Cr ⁶ to Cr ³ ☐ ☐ ☐ (c) Precipitation by Raising pH (After b) ☐ ☐ ☐ (d) Ion Exchange ☐ ☐ ☐ (e) Other (Specify) ☐ ☐ ☐																				
If "YES", check which method.			2.5 DO YOU HAVE TREATMENT TO REMOVE OTHER METALS? ☐ YES ☐ NO ☐ PLANNED																				
☐ (a) Evaporation & Condensation ☐ (c) Filtration ☐ (b) Ion Exchange ☐ (d) Other (Specify)			If "YES", check which method used.																				
1.6 DO YOU REGENERATE SPENT PROCESS BATHS? ☐ YES ☐ NO			BATCH MECH. AUTO AUTO CONTINUOUS (a) Precipitation ☐ ☐ ☐ (b) Ion Exchange ☐ ☐ ☐ (c) Reverse Osmosis ☐ ☐ ☐ (d) Activated Carbon ☐ ☐ ☐ (e) Other (Specify) ☐ ☐ ☐																				
If "YES", list which baths and regeneration method.			2.6 PLEASE SHOW ON A SEPARATE SHEET OF PAPER, A SCHEMATIC LAYOUT OF YOUR ENTIRE TREATMENT SYSTEM.																				
PROCESS BATHS	REGENERATION METHOD																						
1.7 HAVE YOU TAKEN MEASURES TO LOWER WATER CONSUMPTION? ☐ YES ☐ NO ☐ PLANNED			G. MONITORING AND RECORDING																				
If "YES", check which method.			1.0 DO YOU MONITOR YOUR WASTE WATERS? ☐ YES ☐ NO																				
☐ (a) Counter Flow Rinsing ☐ (c) Spray Rinsing ☐ (b) Conductivity Control ☐ (d) Other (Specify)			If "YES", indicate the frequency and method of sampling.																				
1.8 INDICATE ANY IN PLANT CONTROLS YOU HAVE TAKEN NOT COVERED ABOVE. (Use additional sheets if necessary)			<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th>FREQUENCY</th> <th>METHOD</th> </tr> </thead> <tbody> <tr> <td>(a) pH</td> <td></td> <td></td> </tr> <tr> <td>(b) CYANIDE</td> <td></td> <td></td> </tr> <tr> <td>(c) METALS</td> <td>(i)</td> <td></td> </tr> <tr> <td></td> <td>(ii)</td> <td></td> </tr> <tr> <td>(d) SUSPENDED SOLIDS</td> <td></td> <td></td> </tr> </tbody> </table>				FREQUENCY	METHOD	(a) pH			(b) CYANIDE			(c) METALS	(i)			(ii)		(d) SUSPENDED SOLIDS		
	FREQUENCY	METHOD																					
(a) pH																							
(b) CYANIDE																							
(c) METALS	(i)																						
	(ii)																						
(d) SUSPENDED SOLIDS																							
			2.0 INDICATE THE TYPE OF EFFLUENT RECORDS WHICH ARE KEPT.																				
			3.0 DO YOU ADVISE ANY AUTHORITY OF THE RESULTS OF YOUR MONITORING? ☐ YES ☐ NO																				
			If "YES", specify which authority																				

TABLE A.1. COMPANIES HAVING ONLY CHEMICAL TREATMENT OF SURFACES: GENERAL INFORMATION

NUMBER OF COMPANIES BY PROVINCE										
	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
NUMBER OF FINISHING EMPLOYEES										
A) 1 - 10	0	1	0	18	48	2	0	4	3	76
B) 11 - 50	0	0	0	5	19	1	0	0	3	28
C) OVER 50	0	0	0	1	9	0	0	0	0	10
CAPTIVE (1) OPERATIONS, NUMBER OF FINISHING EMPLOYEES										
A) 1 - 10	0	1	0	15	47	2	0	2	1	68
B) 11 - 50	0	0	0	4	16	1	0	0	3	24
C) OVER 50	0	0	0	1	7	0	0	0	0	8
KNOWN TO AUTHORITIES										
A) PROVINCIAL	0	0	0	4	16	0	0	2	1	23
B) PROV & MUNICIPAL	0	0	0	6	37	0	0	1	4	48
C) MUNICIPAL	0	0	0	6	14	0	0	0	1	21
D) NEITHER	0	1	0	8	9	3	0	1	0	22
WASTE WATER TO										
A) MUNICIPAL SANITARY SEWER	0	1	0	7	48	1	0	1	1	59
B) OTHER	0	0	0	13	21	1	0	3	5	43
C) NOT REPORTED	0	0	0	4	7	1	0	0	0	12
TOTAL COMPANIES RESPONDING TO SURVEY	0	1	0	24	76	3	0	4	6	114

(1) For the purpose of this survey an operation was assumed as captive when the number of employees in the metal fabricating section was higher than the number in the metal finishing section.

TABLE A.2. COMPANIES HAVING ELECTROPLATING AND CYANIDE HARDENING OF SURFACES: GENERAL INFORMATION

NUMBER OF COMPANIES BY PROVINCE											
		NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
NUMBER OF FINISHING EMPLOYEES											
A) 1 - 10		0	2	1	21	56	5	2	8	18	113
B) 11 - 50		0	0	0	10	59	3	0	3	5	80
C) OVER 50		0	0	0	7	26	0	0	0	1	34
CAPTIVE OPERATIONS NUMBERS OF FINISHING EMPLOYEES											
A) 1 - 10		0	1	1	15	38	3	0	1	6	65
B) 11 - 50		0	0	0	8	36	3	0	0	2	49
C) OVER 50		0	0	0	6	20	0	0	0	1	27
KNOWN TO AUTHORITIES											
A) PROVINCIAL		0	1	0	8	32	2	0	0	4	47
B) PROV & MUNICIPAL		0	1	1	14	66	2	0	4	11	99
C) MUNICIPAL		0	0	0	8	31	2	0	4	6	51
D) NEITHER		0	0	0	8	12	2	2	3	3	30
WASTE WATER TO											
A) MUNICIPAL SANITARY SEWER		0	1	1	30	102	5	1	5	14	159
B) OTHER		0	1	0	4	23	3	1	4	7	43
C) NOT REPORTED		0	0	0	4	16	0	0	2	3	25
TOTAL COMPANIES RESPONDING TO SURVEY		0	2	1	38	141	8	2	11	24	227

TABLE A.3 (a). PROCESS INFORMATION

NO OF COMPANIES USING THE FOLLOWING CHEMICAL PROCESSES - BY PROV (1)

	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
DE-GREASING:VAPOUR	0	0	0	7	21	1	0	1	2	32
DE-GREASING:EMULSION	0	0	0	2	14	1	0	2	1	20
DE-GREASING:DETERGENT	0	0	0	6	35	0	0	1	0	42
PICKLING	0	0	0	6	17	1	0	3	3	30
DE-RUSTING	0	0	0	1	2	0	0	0	0	3
STRIPPING METAL COATINGS	0	0	0	2	4	0	0	0	0	6
PASSIVATING	0	0	0	2	1	0	0	0	1	4
ACTIVATING	0	0	0	0	2	0	0	0	0	2
PHOSPHATING	0	1	0	6	36	1	0	1	2	47
CHROMATING	0	0	0	1	14	0	0	0	0	15
BRIGHT DIPPING	0	0	0	1	4	0	0	0	1	6
TOTAL COMPANIES RESPONDING TO SURVEY	0	1	0	24	76	3	0	4	6	114

(1) The companies listed above have chemical processes only.

TABLE A.3(b). PROCESS INFORMATION

NO OF CHEM FINISHING PROCESSES IN ELECTROPLATING & HARDENING CO'S BY PROV (1)										
	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
DE-GREASING:VAPOUR	0	0	0	15	74	2	0	3	7	101
DE-GREASING:EMULSION	0	0	0	10	23	0	0	2	1	36
DE-GREASING:DETERGENT	0	1	1	22	79	3	0	5	12	123
PICKLING	0	1	0	23	65	4	0	5	13	111
DE-RUSTING	0	0	0	11	14	0	1	1	2	29
STRIPPING METAL COATINGS	0	0	0	13	37	4	2	3	9	68
PASSIVATING	0	0	0	9	14	2	0	0	1	26
ACTIVATING	0	0	0	6	17	0	0	2	3	28
PHOSPHATING	0	0	0	13	33	2	0	2	3	53
CHROMATING	0	0	0	15	44	2	0	4	6	71
BRIGHT DIPPING	0	0	0	13	35	3	0	0	4	55
TOTAL COMPANIES RESPONDING TO SURVEY	0	2	1	38	141	8	2	11	24	227

(1) chemical processes which are part of companies having also electroplating and hardening processes.

TABLE A.3(c). PROCESS INFORMATION

NO OF CO'S USING THE FOLLOWING ELECTROPLATING & HARDENING PROCESSES - BY PROV.

	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
ELECTROLESS COPPER PLATING	0	0	0	8	7	0	0	0	2	17
ELECTROLESS NICKEL PLATING	0	0	0	7	7	0	0	1	2	17
HARDENING (cyanide)	0	0	0		8	0	0	1	3	18
ELECTROCLEANING	0	0	0	14	97	3	1	5	14	134
ETCHING	0	0	1	9	30	2	1	3	3	49
ANODIZING:SULPHURIC	0	0	1	11	24	1	0	1	3	41
ANODIZING:CHROMIC	0	0	0	4	9	1	0	0	0	14
LEAD PLATING	0	0	0	4	3	0	0	0	0	7
COPPER PLATING:CYANIDE	0	0	0	16	57	2	1	4	9	89
COPPER PLATING:ACID	0	0	0	4	16	1	0	3	4	28
NICKEL PLATING:BRIGHT	0	0	0	14	73	3	1	6	12	109
NICKEL PLATING:SEMI-BRIGHT	0	0	0	6	37	1	0	2	5	51
CHROMIUM PLATING	0	1	0	12	75	2	2	9	16	117
TIN PLATING	0	0	0	8	28	1	0	0	1	38
ZINC PLATING:CYANIDE	0	0	0	11	41	2	0	3	5	62
ZINC PLATING:NON-CYANIDE	0	0	0	1	11	1	0	1	0	14
CADMIUM PLATING	0	1	0	12	40	1	0	2	3	59
BRASS PLATING	0	0	0	4	19	1	0	1	4	29
GOLD PLATING	0	0	0	7	10	2	0	0	3	22
SILVER PLATING	0	0	0	10	21	3	0	0	6	40
ELECTROPOLISHING	0	0	0	2	4	0	0	0	0	6
TOTAL COMPANIES RESPONDING TO SURVEY	0	2	1	38	141	8	2	11	24	227

TABLE A.4. COMPANIES HAVING ONLY CHEMICAL TREATMENT OF SURFACES:
AVAILABLE INFORMATION ON WASTE DISPOSAL

		NUMBER OF COMPANIES BY PROVINCE									
		NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
DISPOSAL OF SPENT BATHS BY SHIPMENT TO DISPOSAL SITES	A) YES	0	0	0	8	26	0	0	1	1	36
	B) NO	0	0	0	10	34	2	0	3	4	53
	C) PLANNED	0	0	0	0	2	0	0	0	1	3
DISPOSAL OF SLUDGES BY SHIPMENT TO DISPOSAL SITES	A) YES	0	0	0	11	50	0	0	2	1	64
	B) NO	0	0	0	6	11	2	0	1	3	23
	C) PLANNED	0	0	0	0	2	0	0	0	1	3
IN PLANT TREATMENT OF DUMPS OF PROCESS BATHS BEFORE DISPOSAL											
	A) YES	0	0	0	5	23	1	0	0	2	31
	B) NO	0	0	0	10	31	1	0	4	3	49
	C) PLANNED	0	0	0	2	3	0	0	0	1	6
TOTAL COMPANIES RESPONDING TO SURVEY		0	1	0	24	76	3	0	4	6	114

TABLE A.5. COMPANIES HAVING ELECTROPLATING AND CYANIDE HARDENING OF SURFACES:
AVAILABLE INFORMATION ON WASTE DISPOSAL

NUMBER OF COMPANIES BY PROVINCE

	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
DISPOSAL OF SPENT BATHS BY SHIPMENT TO DISPOSAL SITES										
A) YES	0	1	0	8	63	3	1	4	8	88
B) NO	0	1	1	21	59	4	1	5	11	103
C) PLANNED	0	0	0	5	8	0	0	2	2	17
DISPOSAL OF SLUDGES BY SHIPMENT TO DISPOSAL SITES										
A) YES	0	2	0	13	97	4	2	7	14	139
B) NO	0	0	1	15	19	1	0	1	3	40
C) PLANNED	0	0	0	4	10	1	0	2	1	18
IN PLANT TREATMENT OF DUMPS OF PROCESS BATHS BEFORE DISPOSAL										
A) YES	0	0	0	9	75	3	0	2	10	99
B) NO	0	2	0	15	39	4	1	5	6	72
C) PLANNED	0	0	1	10	11	0	0	1	3	26
TOTAL COMPANIES RESPONDING TO SURVEY	0	2	1	38	141	8	2	11	24	227

TABLE A.6. COMPANIES HAVING ONLY CHEMICAL TREATMENT OF SURFACES:
IN PLANT MEASURES FOR WASTEWATER POLLUTION CONTROL

	NUMBER OF COMPANIES BY PROVINCE									
	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
SEPARATELY PIPING STREAM(S) :										
CYANIDE	0	0	0	12	33	0	0	2	3	50
NITRITE	0	0	0	1	1	0	0	0	0	2
CHROMIUM	0	0	0	1	1	0	0	0	0	2
OIL	0	0	0	1	5	0	0	0	0	6
ACIDS-ALKALI	0	0	0	2	6	0	0	2	0	10
COOLING WATER	0	0	0	8	14	0	0	1	3	26
CONCENTRATED DUMPS	0	0	0	7	20	0	0	0	2	29
	0	0	0	1	7	0	0	0	1	9
RECOVER CHEM WITH RECLAIM TANK :	0	1	0	3	1	0	0	0	1	6
RECOVER CHEM FROM RINSE WATER :	0	0	0	2	1	0	0	0	0	3
CHEMICAL RECOVERY	0	0	0	1	0	0	0	0	0	1
EVAPORATION	0	0	0	1	0	0	0	0	0	1
ION EXCHANGE	0	0	0	0	0	0	0	0	0	0
OTHER	0	0	0	1	1	0	0	0	0	2
PLANNED	0	0	0	1	2	0	0	0	1	4
RECOVER OR RECYCLE RINSE WATER :	0	0	0	1	12	0	0	0	1	14
EVAP & CONDENSATION	0	0	0	1	0	0	0	0	0	1
ION EXCHANGE	0	0	0	0	0	0	0	0	0	0
FILTRATION	0	0	0	0	2	0	0	0	0	2
OTHER	0	0	0	0	9	0	0	0	1	10
PLANNED	0	0	0	1	5	0	0	0	0	6
REGENERATING SPENT BATHS :	0	0	0	6	10	0	0	0	0	16
CONTROLLING WATER CONSUMPTION :	0	1	0	6	32	0	0	0	3	42
COUNTER FLOW RINSE	0	0	0	1	6	0	0	0	1	8
CONDUCTIVITY CONTROL	0	0	0	0	1	0	0	0	1	2
SPRAY RINSING	0	1	0	3	7	0	0	0	1	12
OTHER	0	0	0	2	27	0	0	0	1	30
PLANNED	0	0	0	2	5	0	0	0	1	8
TOTAL COMPANIES RESPONDING TO SURVEY	0	1	0	24	76	3	0	4	6	114

TABLE A.7. COMPANIES HAVING ELECTROPLATING AND CYANIDE HARDENING OF SURFACES:
IN PLANT MEASURES FOR WASTEWATER POLLUTION CONTROL

NUMBER OF COMPANIES BY PROVINCE

	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
SEPARATELY PIPING STREAM(S) :										
CYANIDE	0	0	1	13	86	4	0	6	12	122
NITRITE	0	0	0	8	42	2	0	4	4	60
CHROMIUM	0	0	0	0	2	0	0	0	0	2
OIL	0	0	0	5	54	1	0	5	6	71
ACIDS-ALKALI	0	0	0	1	13	0	0	1	1	16
COOLING WATER	0	0	1	10	68	2	0	3	5	89
CONCENTRATED DUMPS	0	0	1	6	47	3	0	2	2	61
RECOVER CHEM WITH RECLAIM TANK :	0	0	0	6	47	1	0	6	7	67
RECOVER CHEM FROM RINSE WATER :	0	0	0	0	14	0	0	4	3	21
CHEMICAL RECOVERY	0	0	0	0	2	0	0	0	1	3
EVAPORATION	0	0	0	0	11	0	0	2	0	13
ION EXCHANGE	0	0	0	0	6	0	0	0	0	6
OTHER	0	0	0	0	3	0	0	1	1	5
PLANNED	0	0	0	3	20	0	0	0	4	27
RECOVER OR RECYCLE RINSE WATER :	0	0	0	5	23	0	0	3	8	39
EVAP & CONDENSATION	0	0	0	0	4	0	0	0	0	4
ION EXCHANGE	0	0	0	1	9	0	0	0	0	10
FILTRATION	0	0	0	1	4	0	0	1	2	8
OTHER	0	0	0	3	10	0	0	0	6	19
PLANNED	0	0	0	2	10	0	0	0	2	14
REGENERATING SPENT BATHS :	0	1	0	17	54	4	1	8	10	95
CONTROLLING WATER CONSUMPTION :	0	0	0	16	84	2	2	5	13	122
COUNTER FLOW RINSE	0	0	0	6	55	1	1	2	7	72
CONDUCTIVITY CONTROL	0	0	0	2	23	1	0	0	5	31
SPRAY RINSING	0	0	0	5	40	2	1	4	6	58
OTHER	0	0	0	8	28	0	1	0	1	38
PLANNED	0	0	0	6	14	2	0	2	3	27
TOTAL COMPANIES RESPONDING TO SURVEY	0	2	1	38	141	8	2	11	24	227

TABLE A.8. COMPANIES HAVING ONLY CHEMICAL TREATMENT OF SURFACES:
EXTERNAL CONTROL MEASURES FOR WASTEWATER POLLUTION CONTROL

	NUMBER OF COMPANIES BY PROVINCE									
	Nfld	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
PH CONTROL-YES										
-PLANNED	0	0	0	3	15	1	0	0	2	21
	0	0	0	2	4	0	0	0	2	8
SOLIDS REMOVAL FROM WASTE WATER:	0	0	0	9	29	0	0	1	3	42
SETTLING	0	0	0	6	24	0	0	1	3	34
FLOTATION	0	0	0	2	7	0	0	0	0	9
FILTRATION	0	0	0	3	9	0	0	0	0	12
OTHER	0	0	0	2	0	0	0	0	1	3
PLANNED	0	0	0	2	3	0	0	0	1	6
CHROMIUM ION CONTROL :										
PRECIPITATION (BA)	0	0	0	1	7	0	0	0	1	9
REDUCTION CR6-CR3	0	0	0	0	0	0	0	0	0	0
PRECIP OF OH	0	0	0	1	7	0	0	0	0	8
ION EXCHANGE	0	0	0	1	7	0	0	0	0	8
OTHER	0	0	0	0	0	0	0	0	0	0
PLANNED	0	0	0	1	2	0	0	0	1	3
OTHER METALS CONTROL :										
PRECIP OF OH	0	0	0	1	6	0	0	0	2	9
ION EXCHANGE	0	0	0	0	6	0	0	0	1	7
REVERSE OSMOSIS	0	0	0	0	0	0	0	0	0	0
ACTIVATED CARBON	0	0	0	0	0	0	0	0	0	0
OTHER	0	0	0	1	0	0	0	0	1	2
PLANNED	0	0	0	1	3	0	0	0	0	4
TOTAL COMPANIES RESPONDING TO SURVEY	0	1	0	24	76	3	0	4	6	114

TABLE A.9. COMPANIES HAVING ELECTROPLATING AND CYANIDE HARDENING OF SURFACES:
EXTERNAL CONTROL MEASURES FOR WASTEWATER POLLUTION CONTROL

NUMBER OF COMPANIES BY PROVINCE

	NFLD	N.S.	N.B.	QUE	DNT	MAN	SASK	ALTA	B.C.	CANADA
PH CONTROL-YES -PLANNED	0	0	0	5	53	2	0	1	4	65
	0	0	0	6	14	1	0	1	3	25
SOLIDS REMOVAL FROM WASTE WATER:	0	0	0	7	65	6	1	4	9	92
SETTLING	0	0	0	7	55	5	0	4	9	80
FLOTATION	0	0	0	0	2	1	0	0	0	3
FILTRATION	0	0	0	0	19	0	1	0	0	20
OTHER	0	0	0	0	1	0	1	0	0	2
PLANNED	0	0	0	5	9	0	0	1	2	17
CYANIDE ION CONTROL:	0	0	0	5	40	1	0	1	7	54
OXIDATION	0	0	0	2	35	0	0	0	4	41
ELECTROCLEANER	0	0	0	0	6	0	0	1	2	9
COMPLEXING (FES04)	0	0	0	3	0	0	0	0	0	3
ELECTROLYTIC	0	0	0	1	4	0	0	0	2	7
OTHER	0	0	0	0	2	1	0	0	0	3
PLANNED	0	0	0	4	8	1	0	1	3	17
CHROMIUM ION CONTROL :	0	0	0	3	49	0	0	0	3	55
PRECIPITATION (BA)	0	0	0	0	8	0	0	0	0	8
REDUCTION CR6-CR3	0	0	0	3	39	0	0	0	2	44
PRECIP OF OH	0	0	0	3	33	0	0	0	1	37
ION EXCHANGE	0	0	0	0	5	0	0	0	0	5
OTHER	0	0	0	0	6	0	0	0	1	7
PLANNED	0	0	0	4	7	1	0	0	6	18
OTHER METALS CONTROL :	0	0	0	3	42	1	0	0	4	50
PRECIP OF OH	0	0	0	2	30	1	0	0	1	34
ION EXCHANGE	0	0	0	0	9	0	0	0	0	9
REVERSE OSMOSIS	0	0	0	0	0	0	0	0	0	0
ACTIVATED CARBON	0	0	0	1	3	0	0	0	3	7
OTHER	0	0	0	0	7	0	0	0	1	8
PLANNED	0	0	0	4	11	0	0	2	2	19
TOTAL COMPANIES RESPONDING TO SURVEY	0	2	1	38	141	8	2	11	24	227

TABLE A.10. COMPANIES HAVING CHEMICAL TREATMENT OF SURFACES:
MONITORING OF WASTEWATER

	NUMBER OF COMPANIES BY PROVINCE									
	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
MONITORING WASTE WATER :										
PH	0	0	0	5	18	0	0	0	3	26
CYANIDE	0	0	0	5	17	0	0	0	3	25
METALS	0	0	0	0	1	0	0	0	0	1
SUSPENDED SOLIDS	0	0	0	3	7	0	0	0	1	11
	0	0	0	4	6	0	0	0	0	10
RECORD KEEPING :	0	0	0	5	17	0	0	0	3	25
AUTHORITIES ADVISED :	0	0	0	1	11	0	0	0	1	13
TOTAL COMPANIES RESPONDING TO SURVEY	0	1	0	24	76	3	0	4	6	114

TABLE A.11. COMPANIES HAVING ELECTROPLATING AND CYANIDE HARDENING OF SURFACES:
MONITORING OF WASTEWATER

NUMBER OF COMPANIES BY PROVINCE										
	NFLD	N.S.	N.B.	QUE	DNT	MAN	SASK	ALTA	B.C.	CANADA
MONITORING WASTE WATER :										
PH	0	0	1	8	67	1	0	1	8	86
CYANIDE	0	0	1	8	66	1	0	1	7	84
METALS	0	0	0	3	33	0	0	0	4	40
SUSPENDED SOLIDS	0	0	0	3	40	0	0	0	3	46
	0	0	0	3	35	0	0	0	2	40
RECORD KEEPING :	0	0	1	6	64	0	0	0	10	81
AUTHORITIES ADVISED :	0	0	0	1	42	0	0	1	5	49
TOTAL COMPANIES RESPONDING TO SURVEY	0	2	1	38	141	8	2	11	24	227

TABLE A.12. CONSUMPTION OF CHEMICALS

LB/YR BY PROVINCE

MAIN CHEMICAL	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
MISC. AND TRADE NAME	-	-	-	147616	2423620	64050	-	21857	44500	2701643
MISC. CHLORIDE	-	-	-	-	70361	-	-	-	-	70361
MISC. CHROMATE	-	-	-	28160	104454	364	-	28	3720	136726
MISC. CYANIDE	-	-	-	832	191040	-	-	-	655	192527
MISC. DICHROMATE	-	-	-	-	4210	-	-	-	-	4210
MISC. NITRATE	-	-	-	64000	-	-	-	-	-	64000
MISC. PHOSPHATE	-	500	-	85136	1699594	700	-	3300	-	1789230
ALUMINUM COMPOUND	-	-	-	33600	-	-	-	-	-	33600
CADMIUM COMPOUND	-	-	-	-	600	-	-	-	-	600
CADMIUM CYANIDE	-	-	-	288	14616	-	-	-	865	15769
CADMIUM OXIDE	-	165	-	2694	5897	92	-	237	170	9255
CHROMIUM FLUORIDE	-	-	-	-	526	-	-	-	-	526
COPPER COMPOUND	-	-	-	-	3024	-	-	220	50	3294
COPPER CYANIDE	-	-	-	48000	195658	175	200	1208	1210	246451
COPPER FLUOBORATE	-	-	-	-	1200	-	-	-	-	1200
COPPER SULPHATE	-	-	-	23728	167628	140	-	770	1875	194141
GOLD COMPOUND	-	-	-	144	194	-	-	-	-	338

TABLE A.12. (CONT'D)

MAIN CHEMICAL	LB/YR BY PROVINCE									
	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
GOLD CHLORIDE	-	-	-	-	83	-	-	-	-	83
GOLD CYANIDE	-	-	-	101	372	14	-	-	36	523
MISC. ACID	-	-	-	38137	107110	-	-	1210	10100	156557
HYDROCHLORIC ACID	-	-	-	1269808	2395554	23100	-	39270	3364667	7092399
CHROMIC ACID	-	1000	-	2055096	985381	6405	1520	35222	60455	1345077
DICHROMIC ACID	-	-	-	-	482	-	-	-	-	482
FLUOBORIC ACID	-	-	-	480	14208	-	-	-	825	15513
FLUORIC ACID	-	-	-	8000	26460	-	-	-	-	34460
NITRIC ACID	-	-	-	134912	167822	14343	-	-	32800	349877
PHOSPHORIC ACID	-	-	-	5	1864182	28000	-	-	350	1892537
SULPHURIC ACID	-	1610	12000	3824790	9048105	57998	4365	10034	1454209	14413111
BORIC ACID	-	-	-	12494	71242	1596	50	1055	4232	90869
PHENOLSULPHONIC ACID	-	-	-	16	1723	-	-	-	-	1739
IRON CHLORIDE	-	-	-	-	-	-	-	-	31000	31000
IRON PHOSPHATE	-	-	-	67216	554592	7000	-	-	100	628908
LEAD FLUOBORATE	-	-	-	176	2160	-	-	-	-	2336
LEAD HYDROFLUOSILICAT	-	-	-	16000	-	-	-	-	-	16000

TABLE A.12. (CONT'D)

LB/YR BY PROVINCE

MAIN CHEMICAL	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
NICKEL COMPOUND	-	-	-	544	35796	-	-	-	-	36340
NICKEL CHLORIDE	-	-	-	18742	115266	3794	75	1583	6349	145809
NICKEL SULPHATE	-	-	-	211347	771023	15960	500	13189	42820	1054839
NICKEL SULFAMATE	-	-	-	14400	550	-	-	-	750	15700
SODIUM CHLORIDE	-	-	-	-	29760	-	-	-	-	29760
SODIUM CHROMATE	-	-	-	208960	120	-	-	-	-	209080
SODIUM CYANIDE	-	500	-	161170	412118	3193	250	2521	11775	591527
SODIUM DICHROMATE	-	-	-	-	14220	-	-	165	-	14385
CAUSTIC SODA	-	85	-	692360	1747851	17495	2080	1760	71193	2532824
SODIUM PHOSPHATE	-	-	-	480	68	-	-	-	-	548
SODIUM SULPHATE	-	-	-	-	12000	-	-	-	-	12000
SODIUM STANNATE	-	-	-	1120	6480	-	-	-	-	7600
SODIUM ACETATE	-	-	-	-	30	-	-	-	-	30
SODIUM CARBONATE	-	335	-	5542	23989	188	-	480	349	30883
SODIUM BCRATE	-	-	-	-	19200	-	-	-	-	19200
SODIUM NITRITE	-	-	-	-	660	-	-	-	-	660
ZINC COMPOUND	-	-	-	6400	1200	-	-	-	-	7600

TABLE A.12. (CONT'D)

MAIN CHEMICAL	LB/YR BY PROVINCE									
	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
ZINC CHLORIDE	-	-	-	-	29280	-	-	-	-	29280
ZINC CYANIDE	-	-	-	70591	274787	4872	-	583	15930	366763
ZINC PHOSPHATE	-	-	-	1120	302760	-	-	1540	66158	371578
ZINC SULPHATE	-	-	-	-	120	-	-	-	-	120
ZINC OXIDE	-	-	-	-	2928	-	-	-	-	2928
AMMONIUM COMPOUND	-	-	-	-	2520	-	-	-	-	2520
AMMONIUM CHLORIDE	-	-	-	-	2340	-	-	330	-	2670
AMMONIUM NITRATE	-	-	-	1248	66	-	-	-	-	1314
AMMONIUM PHOSPHATE	-	-	-	-	8100	-	-	-	-	8100
SILVER COMPOUND	-	-	-	-	-	-	-	-	-	-
SILVER CYANIDE	-	-	-	557	7098	164	-	-	150	7969
POTASSIUM COMPOUND	-	-	-	-	-	-	-	-	-	-
POTASSIUM CYANIDE	-	-	-	9574	24240	204	-	-	1997	36015
POTASSIUM DICHROMATE	-	-	-	-	8640	-	-	-	1	8641
POTASSIUM HYDROXIDE	-	-	-	2686	516	63	-	-	9	3274
POTASSIUM PHOSPHATE	-	-	-	3200	-	-	-	-	-	3200
POTASSIUM STANNATE	-	-	-	10677	4432	560	-	-	25	15694

TABLE A.12. (CONT'D)

LB/YR BY PROVINCE

MAIN CHEMICAL	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
POTASSIUM CARBONATE	-	-	-	115	701	34	-	-	30	880
TIN COMPOUND	-	-	-	-	3035	-	-	-	-	3035
STANNUS CHLORIDE	-	-	-	-	-	-	-	-	6	6
TIN CYANIDE	-	-	-	-	2195	-	-	-	-	2195
TIN FLUOBORATE	-	-	-	16000	12444.	-	-	-	-	28444
TIN SULPHATE	-	-	-	16	1723	-	-	-	-	1739
TIN OXIDE	-	-	-	-	600	-	-	-	-	600
ALDEHYDES	-	-	-	-	2400	-	-	-	-	2400
SOAP	-	-	-	-	1440	-	-	-	-	1440
DETERGENTS	-	200	3000	300024	1821954	1568	-	21203	16652	2164601
PHOSPHATE DETERGENT	-	-	-	-	8400	-	-	770	-	9170
PAINTS	-	-	-	-	43200	-	-	-	-	43200
CHLORINATED HYDROCARB	-	-	-	1848112	3056348	258440	-	22022	187509	5372431
CITRIC ACID	-	-	-	-	14411	-	-	-	-	14411
OIL	-	-	-	-	4980	-	-	330	1100	6410
ALKALINE CLEANERS	-	-	-	103840	407622	18760	4200	8250	68200	610872
HYDROCARBON SOLVENTS	-	-	-	130080	97800	-	-	-	-	227880

TALBE A.12. (CONT'D)

MAIN CHEMICAL	LB/YR BY PROVINCE									
	Nfld	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
FREON	-	-	-	4000	-	-	-	-	-	4000

- Note 1 - Consumption from chemical electrolytic and cyanide hardening processes are combined in this table.
- Note 2 - Quantities have been adjusted to cover companies not responding to the survey.
- Note 3 - Miscellaneous and trade name indicates chemicals for which the analysis was not available.

Table A.13 contains the consumption of chemicals as reported by companies in both sections C.4 and C.5 of the questionnaire.

The original information has been adjusted to include, as explained in section 2, secondary chemicals used in conjunction with the main chemicals reported. Adjustments were also made to include chemical consumption of companies not replying to the questionnaire but which are part of the segment of the metal finishing industry under study.

Table A.14 shows the number of processes on which table A.13 is based, before any adjustment.

Table A.15 is derived from Table A.13 and shows the quantities of chemicals used expressed as ions.

Table A.16 shows the consumption of metal anodes as reported by the companies in section C.5 of the questionnaire. As in Table A.13 the original information has been adjusted to include companies not replying to the questionnaire.

TABLE A.13. CONSUMPTION OF CHEMICALS BY METAL FINISHING PROCESS

PROCESS	MAIN CHEMICAL	LB/YR BY PROVINCE				
		QUE	ONT	MAN	ALTA	B.C. CANADA
DE-GREASING:VAPOUR	MISC. AND TRADE NAME	4000	1020180	-	-	1024180
	CHLORINATED HYDROCARB	1842960	3052854	258440	19030	5359293
DE-GREASING:EMULSION	MISC. AND TRADE NAME	62400	34428	-	8800	105628
	PHOSPHORIC ACID	-	28800	-	-	28800
	SULPHURIC ACID	-	21000	-	-	21000
	IRON PHOSPHATE	-	2880	-	-	2880
	CAUSTIC SODA	-	302400	-	-	302400
	DETERGENTS	9120	84216	-	-	100136
	CHLORINATED HYDROCARB	135232	97800	-	2992	236024
	ALKALINE CLEANERS	-	66206	-	-	66606
	MISC. AND TRADE NAME	-	88800	-	-	88800
	MISC. PHOSPHATE	-	-	-	-	-
DE-GREASING:DETERGENT	IRON PHOSPHATE	-	8400	-	-	8400
	CAUSTIC SODA	7680	176340	-	-	191120
	DETERGENTS	290904	1154906	1568	16803	1477233
	PHOSPHATE DETERGENT	-	8400	-	550	8950
	ALKALINE CLEANERS	12960	120888	8400	-	174173
	MISC. AND TRADE NAME	-	75600	13440	3080	132120
	MISC. CYANIDE	32	-	-	-	32
PICKLING	MISC. ACID	10635	64920	-	1210	86865
	HYDROCHLORIC ACID	873120	2258508	1540	31196	6527151
	CHROMIC ACID	6400	36	-	-	6436
	FLUOBORIC ACID	-	5808	-	-	5808
	FLUORIC ACID	4800	26460	-	-	31260
	NITRIC ACID	70224	37092	-	-	107366
	PHOSPHORIC ACID	-	34800	-	50	34800
		-	-	-	-	-

* SEE END OF TABLE FOR OTHER PROVINCES

TABLE A.13. (CONT'D)

PROCESS	MAIN CHEMICAL	LB/YR BY PROVINCE					
		QUE	ONT	MAN	ALTA	B.C.	CANADA
PICKLING	SULPHURIC ACID	3398360	4495272	1904	8800	1413837	9319773 *
	SODIUM CHROMATE	208000	-	-	-	-	208000
	CAUSTIC SODA	-	132360	-	-	-	132360
DE-RUSTING	MISC. AND TRADE NAME	7600	18824	-	-	-	26424
	MISC. ACID	24000	-	-	-	-	24000
	HYDROCHLORIC ACID	361488	36510	-	924	900	399822
	CHROMIC ACID	-	192	-	-	-	192
	NITRIC ACID	-	360	-	-	-	360
	SULPHURIC ACID	-	30024	-	-	-	30774 *
	DETERGENTS	-	12000	-	-	-	12000
	CITRIC ACID	-	14400	-	-	-	14400
STRIPPING METAL COATING	MISC. AND TRADE NAME	22848	110465	-	253	-	133566
	MISC. CYANIDE	800	-	-	-	25	825
	HYDROCHLORIC ACID	-	33840	21560	550	980	56930
	CHROMIC ACID	-	-	-	-	20	20
	FLUOBORIC ACID	-	-	-	-	825	825
	NITRIC ACID	26000	26088	-	-	26500	78588
	SULPHURIC ACID	-	23052	-	-	-	23052
	SODIUM CYANIDE	50400	3108	294	-	2820	56622
	CAUSTIC SODA	102400	4476	-	-	2200	111076 *
	SODIUM SULPHATE	-	12000	-	-	-	12000
	DETERGENTS	-	33360	-	-	-	33360
PASSIVATING	MISC. AND TRADE NAME	4800	20400	-	-	1	25201
	MISC. DICHROMATE	-	250	-	-	-	250
	CHROMIC ACID	-	552	-	-	-	552
	DICHROMIC ACID	-	-	-	-	-	-

* SEE END OF TABLE FOR OTHER PROVINCES

TABLE A.13. (CONT'D)

PROCESS	MAIN CHEMICAL	QUE	LB/YR BY PROVINCE				CANADA
			DNT	MAN	ALTA	B.C.	
PASSIVATING	NITRIC ACID	29296	14000	12418	-	300	56014
	SULPHURIC ACID	-	3600	-	-	-	3600
ACTIVATING	MISC. AND TRADE NAME	5	2040	-	440	6	2491
	MISC. CHROMATE	-	61	-	-	-	61
	CHROMIUM FLUORIDE	-	526	-	-	-	526
	MISC. ACID	-	9132	-	-	-	9132
	HYDROCHLORIC ACID	-	696	-	-	-	696
	NITRIC ACID	32	-	-	-	450	482
	SULPHURIC ACID	-	240845	-	-	3600	244445
	CAUSTIC SODA	6480	36	-	-	-	6516
PHOSPHATING	MISC. AND TRADE NAME	-	93090	-	-	-	93090
	MISC. PHOSPHATE	85600	507598	700	3300	-	597698 *
	NITRIC ACID	400	-	-	-	-	400
	PHOSPHORIC ACID	-	71730	-	-	150	71880
	IRON PHOSPHATE	67216	543312	7000	-	100	617628
	ZINC PHOSPHATE	1120	302760	-	1540	66158	371578
CHROMATING	MISC. AND TRADE NAME	-	5888	-	-	-	6888
	MISC. CHROMATE	29120	104273	364	28	3710	137495
	MISC. DICHROMATE	-	3960	-	-	-	3960
	CHROMIC ACID	20080	27887	-	-	220	48187
	DICHROMIC ACID	-	482	-	-	-	482
	NITRIC ACID	-	-	315	-	-	315
	SODIUM DICHROMATE	-	14220	-	165	-	14385
	POTASSIUM DICHROMATE	-	8640	-	-	-	8640
ELECTROLESS COPPER PLAT	MISC. AND TRADE NAME	128	2915	-	-	-	3043

* SEE END OF TABLE FOR OTHER PROVINCES

TABLE A.13. (CONT'D)

PROCESS	MAIN CHEMICAL	LB/YR BY PROVINCE				
		QUE	ONT	MAN	ALTA	B.C.
ELECTROLESS COPPER PLAT	COPPER COMPOUND	-	3024	-	-	50
	COPPER CYANIDE	-	-	-	-	-
	COPPER SULPHATE	21760	61200	-	-	-
ELECTROLESS NICKEL PLAT	MISC. AND TRADE NAME	320	8436	-	-	-
	PHOSPHORIC ACID	5	-	-	-	-
	NICKEL SULPHATE	86400	49920	-	2640	-
BRIGHT DIPPING	MISC. AND TRADE NAME	6400	186	-	-	-
	MISC. CHROMATE	-	-	-	-	10
	MISC. PHOSPHATE	16	1200000	-	-	-
	ALUMINUM COMPOUND	33600	-	-	-	-
	MISC. ACID	2974	1440	-	-	-
	CHROMIC ACID	3840	5772	-	-	15
	NITRIC ACID	8960	63978	1610	-	5500
	PHOSPHORIC ACID	-	1726452	28000	-	200
	SULPHURIC ACID	52320	422537	-	-	-
						474857
HARDENING	MISC. AND TRADE NAME	35299	2880	-	-	3600
	MISC. CHLORIDE	-	22800	-	-	-
	MISC. CYANIDE	-	190080	-	-	100
	MISC. NITRATE	64000	-	-	-	-
	SODIUM CYANIDE	12640	45138	-	-	-
	OIL	-	3360	-	330	-
OTHER	MISC. AND TRADE NAME	9408	460812	-	4730	2000
	MISC. CHROMATE	-	-	-	-	-
	MISC. CYANIDE	-	-	-	-	-
	MISC. PHOSPHATE	-	90	-	-	-
						90
						476950
						-
						-
						82960
						3074
						8756
						5
						138960
						6586
						10
						1200016
						33600
						4414
						9627
						80048
						1754652
						474857
						41779
						22800
						190150
						64000
						57778
						3690

TABLE A.13. (CONT'D)

OTHER	PROCESS	MAIN CHEMICAL	LB/YR BY PROVINCE					
			QUE	ONT	MAN	ALTA	B.C.	CANADA
		MISC. ACID	-	720	-	-	-	720
		HYDROCHLORIC ACID	-	14400	-	-	-	14400
		CHROMIC ACID	8	3000	-	-	-	3008
		NITRIC ACID	-	25344	-	-	-	25344
		SULPHURIC ACID	192080	10754	-	-	-	202834
		IRON CHLORIDE	-	-	-	-	30000	30000
		CAUSTIC SODA	132640	86160	-	-	4000	222800
		SODIUM BORATE	-	19200	-	-	-	19200
		ZINC CHLORIDE	-	14400	-	-	-	14400
		PAINTS	-	43200	-	-	-	43200

TABLE A.13. (CONT'D)

PROCESS	MAIN CHEMICAL	LB/YR BY PROVINCE					CANADA
		QUE	ONT	MAN	ALTA	B.C.	
ELECTROCLEANING	MISC. AND TRADE NAME						
	CAUSTIC SODA	499	355416	-	3960	1500	361375
	DETERGENTS	1984	153984	-	-	4680	160648
	ALKALINE CLEANERS	90890	532672	-	-	-	532672
			219628	10360	8250	35875	369193 *
ETCHING	MISC. AND TRADE NAME						
	MISC. ACID	4320	195384	50400	5544	-	255648
	HYDROCHLORIC ACID	528	30898	-	-	-	31426
	CHROMIC ACID	35200	49800	-	-	-	85000
	SULPHURIC ACID	17600	43638	-	2640	-	63878
	IRON CHLORIDE	-	1708223	-	-	14000	1725823
	CAUSTIC SODA	312000	405120	7980	275	1000	1000
ANODIZING:SULPHURIC	SULPHURIC ACID	144672	1102315	56000	715	21600	1337302 *
ANODIZING:CHROMIC	CHROMIC ACID	7168	40068	525	-	-	47761
LEAD PLATING	FLUOBORIC ACID	480	-	-	-	-	480
	FLUORIC ACID	3200	-	-	-	-	3200
	LEAD FLUOBORATE	16	2160	-	-	-	2176
	LEAD HYDROFLUOSILICAT	16000	-	-	-	-	16000
COPPER PLATING:CYANIDE	MISC. CYANIDE	-	1080	-	-	150	1230
	COPPER CYANIDE	48000	159935	147	1208	932	209422 *
	SODIUM CYANIDE	56000	190874	183	1509	464	250280 *
	CAUSTIC SODA	13512	61241	59	483	148	75523 *
	POTASSIUM CYANIDE	8032	19920	-	-	1800	29752
COPPER PLATING:ACID	MISC. AND TRADE NAME	3200	-	-	-	-	3200

* SEE END OF TABLE FOR OTHER PROVINCES

TABLE A.13. (CONT'D)

PROCESS	MAIN CHEMICAL	LB/YR BY PROVINCE					CANADA
		QUE	ONT	MAN	ALTA	B.C.	
COPPER PLATING:ACID	COPPER COMPOUND	-	-	-	220	-	220
	COPPER FLUOBORATE	-	1200	-	-	-	1200
	COPPER SULPHATE	1968	106428	140	770	1875	111181
	HYDROCHLORIC ACID	-	1800	-	-	-	1800
	SULPHURIC ACID	493	25699	35	193	469	27839
NICKEL PLATING:BRIGHT	BORIC ACID	12000	37247	616	752	2757	53422
	NICKEL CHLORIDE	18000	55873	924	1129	4136	80137
	NICKEL SULPHATE		372461	6160	7524	27570	534215
NICKEL PLATING:SEMI-BRI	BORIC ACID	494	33995	980	303	1475	37247
	NICKEL CHLORIDE	742	50993	1470	454	2213	55872
	NICKEL SULPHATE	4947	339942	9800	3025	14750	372464
	NICKEL SULFAMATE	14400	550	-	-	750	15700
CHROMIUM PLATING	CHROMIC ACID	200000	840236	5880	32582	60200	1141418
	SULPHURIC ACID	1646	8404	59	326	603	11063
TIN PLATING	MISC. AND TRADE NAME	16	4843	-	-	-	4859
	SULPHURIC ACID	19	1980	-	-	-	1999
	PHENOLSULPHONIC ACID	16	1723	-	-	-	1739
	SODIUM STANNATE	1120	6480	-	-	-	7600
	POTASSIUM HYDROXIDE	1067	389	56	-	3	1515
	POTASSIUM STANNATE	10677	3884	560	-	25	15146
	TIN FLUOBORATE	16000	12444	-	-	-	28444
ZINC PLATING:CYANIDE	SODIUM CYANIDE	32808	151921	2436	297	7973	195435
	CAUSTIC SODA	109021	397487	7308	880	23875	538571
	ZINC CYANIDE	65013	274367	4872	583	15902	360737

* SEE END OF TABLE FOR OTHER PROVINCES

TABLE A.13. (CONT'D)

PROCESS	MAIN CHEMICAL	QUE	LB/YR BY PROVINCE				CANADA
			ONT	MAN	ALTA	B.C.	
ZINC PLATING:NON-CYANID	MISC. AND TRADE NAME						
	MISC. CHLORIDE	-	3900	-	-	-	3900
	SODIUM CHLORIDE	-	41561	-	-	-	41561
	CAUSTIC SODA	-	29760	-	-	-	29760
	SODIUM ACETATE	-	-	2100	-	-	2100
CADMIUM PLATING	ZINC CHLORIDE	-	30	-	-	-	30
		-	14880	-	-	-	14880
	MISC. AND TRADE NAME	1424	3047	48	122	90	4816 *
	MISC. CHLORIDE	-	6000	-	-	-	6000
	MISC. CYANIDE	-	720	-	-	-	720
BRASS PLATING	CADMIUM COMPOUND	-	600	-	-	-	600
	CADMIUM CYANIDE	288	14616	-	-	865	15769
	CADMIUM OXIDE	2694	5897	92	237	170	9255 *
	SODIUM CYANIDE	8237	17885	280	715	518	28135 *
	SODIUM CARBONATE	5542	11989	188	480	349	18883 *
GOLD PLATING	MISC. AND TRADE NAME	6760	1092	-	-	-	7852
	MISC. CYANIDE	-	240	-	-	-	240
	COPPER CYANIDE	-	31733	28	-	250	32011
	ZINC CYANIDE	5578	420	-	-	28	6026
SILVER PLATING	MISC. AND TRADE NAME	-	11	210	-	-	221
	GOLD COMPOUND	144	194	-	-	-	338
	GOLD CHLORIDE	-	83	-	-	-	83
	GOLD CYANIDE	101	372	14	-	36	523
	POTASSIUM CYANIDE	51	182	7	-	18	258
	MISC. AND TRADE NAME	-	-	-	-	-	-
	CAUSTIC SODA	-	3600	-	-	-	3600

* SEE END OF TABLE FOR OTHER PROVINCES

TABLE A.13 (CONT'D)

PROCESS	MAIN CHEMICAL	LB/YR BY PROVINCE					CANADA
		QUE	ONT	MAN	ALTA	B.C.	
SILVER PLATING	SILVER CYANIDE	557	3438	164	-	150	4309
	POTASSIUM CYANIDE	672	4138	197	-	179	5186
	POTASSIUM HYDROXIDE	19	127	7	-	6	159
	POTASSIUM CARBONATE	115	701	34	-	30	880
ELECTROCLEANING	MISC. AND TRADE NAME	800	68	-	-	-	868
	FLUOBORIC ACID	-	8400	-	-	-	8400
	PHOSPHORIC ACID	-	2400	-	-	-	2400
	SULPHURIC ACID	19200	660000	-	-	-	679200
OTHER	MISC. AND TRADE NAME	2944	15259	1400	-	-	19603
	MISC. CHROMATE	-	240	-	-	-	240
	MISC. CYANIDE	-	-	-	-	380	380
	MISC. PHOSPHATE	-	6	-	-	-	6
	COPPER CYANIDE	-	4990	-	-	28	5018
	HYDROCHLORIC ACID	-	-	-	6600	-	6600
	CHROMIC ACID	-	24000	-	-	-	24000
	NITRIC ACID	-	960	-	-	-	960
	SULPHURIC ACID	16000	293400	-	-	100	309500
	LEAD FLUOBORATE	160	-	-	-	-	160
	NICKEL SULPHATE	-	5040	-	-	500	5540
	CAUSTIC SODA	-	21600	-	-	5100	26700

TABLE A.13. (CONT'D)

*CONSUMPTIONS RECORDED IN OTHER PROVINCES, (INCLUDED IN CANADA TOTAL)					
PROCESS	MAIN CHEMICAL	NFLD	N.S.	N.B.	SASK
DE-GREASING:DETERGENT	DETERGENTS	-	200	3000	-
PICKLING	SULPHURIC ACID	-	1600	-	-
DE-RUSTING	SULPHURIC ACID	-	-	-	750
STRIPPING METAL COATING	CAUSTIC SODA	-	-	-	2000
PHOSPHATING	MISC. PHOSPHATE	-	500	-	-
ELECTROLYTIC PROCESS	MAIN CHEMICAL				
ELECTROCLEANING	ALKALINE CLEANERS	-	-	-	4200
ETCHING	SULPHURIC ACID	-	-	-	3600
ANODIZING:SULPHURIC	SULPHURIC ACID	-	-	12000	-
COPPER PLATING:CYANIDE	COPPER CYANIDE	-	-	-	200
	SODIUM CYANIDE	-	-	-	250
	CAUSTIC SODA	-	-	-	80
	BORIC ACID	-	-	-	50
NICKEL PLATING:BRIGHT	NICKEL CHLORIDE	-	-	-	75
	NICKEL SULPHATE	-	-	-	500
CHROMIUM PLATING	CHROMIC ACID	-	1000	-	1520
	SULPHURIC ACID	-	10	-	15
CADMIUM PLATING	MISC. AND TRADE NAME	-	85	-	-
	CADMIUM OXIDE	-	165	-	-
	SODIUM CYANIDE	-	500	-	-
	SODIUM CARBONATE	-	335	-	-

NOTE 1: Consumption from chemical, electrolytic and hardening processes are combined in this table

NOTE 2: Quantities have been adjusted to cover companies not responding to the survey

NOTE 3: "Miscellaneous and trade name" indicates chemicals for which the analysis was not available.

TABLE A.14. NUMBER OF PROCESSES RESPONDING IN TABLE A.13.

PROCESS	MAIN CHEMICAL	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
DE-GREASING:VAPOUR	MISC. AND TRADE NAME	-	-	-	1	11	-	-	-	1	13
	CHLORINATED HYDROCARB	-	-	-	21	88	3	-	4	10	126
DE-GREASING:EMULSION	MISC. AND TRADE NAME	-	-	-	2	6	-	-	2	-	10
	PHOSPHORIC ACID	-	-	-	-	1	-	-	-	-	1
	SULPHURIC ACID	-	-	-	1	1	-	-	-	-	2
	IRON PHOSPHATE	-	-	-	-	1	-	-	-	-	1
	CAUSTIC SODA	-	-	-	-	5	1	-	-	-	6
	DETERGENTS	-	-	-	1	17	-	-	-	1	19
	CHLORINATED HYDROCARB	-	-	-	9	2	-	-	2	-	13
	ALKALINE CLEANERS	-	-	-	-	5	-	-	-	2	7
	MISC. AND TRADE NAME	-	-	-	-	17	-	-	-	-	17
DE-GREASING:DETERGENT	MISC. PHOSPHATE	-	-	-	1	-	-	-	-	-	1
	IRON PHOSPHATE	-	-	-	-	1	-	-	-	-	1
	CAUSTIC SODA	-	-	-	1	8	-	-	-	2	11
	DETERGENTS	-	1	1	29	88	2	-	6	7	134
	PHOSPHATE DETERGENT	-	-	-	-	1	-	-	1	-	2
	ALKALINE CLEANERS	-	-	-	1	9	1	-	-	5	16
	MISC. AND TRADE NAME	-	-	-	-	6	1	-	2	1	10
	MISC. CYANIDE	-	-	-	1	-	-	-	-	-	1
PICKLING	MISC. ACID	-	-	-	5	5	-	-	2	4	16
	HYDROCHLORIC ACID	-	-	-	15	45	1	-	2	9	72
	CHROMIC ACID	-	-	-	1	1	1	-	-	-	3
	FLUOBORIC ACID	-	-	-	-	1	-	-	-	-	1
	FLUORIC ACID	-	-	-	1	2	-	-	-	-	3
	NITRIC ACID	-	-	-	7	6	-	-	-	1	14
	PHOSPHORIC ACID	-	-	-	-	2	-	-	-	-	2
	MISC. AND TRADE NAME	-	-	-	-	6	1	-	2	1	10

TABLE A.14. (CONT'D)

PROCESS	MAIN CHEMICAL	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
PICKLING	SULPHURIC ACID	-	1	-	11	31	3	-	3	6	55
	SODIUM CHROMATE	-	-	-	1	-	-	-	-	-	1
	CAUSTIC SODA	-	-	-	-	3	-	-	-	-	3
DE-RUSTING	MISC. AND TRADE NAME	-	-	-	6	6	-	-	-	1	13
	MISC. ACID	-	-	-	1	-	-	-	-	-	1
	HYDROCHLORIC ACID	-	-	-	5	4	-	-	1	1	11
	CHROMIC ACID	-	-	-	-	1	-	-	-	-	1
	NITRIC ACID	-	-	-	-	1	-	-	-	-	1
	SULPHURIC ACID	-	-	-	-	2	-	1	-	-	3
	DETERGENTS	-	-	-	-	1	-	-	-	-	1
	CITRIC ACID	-	-	-	-	1	-	-	-	-	1
STRIPPING METAL COATING	MISC. AND TRADE NAME	-	-	-	5	18	1	1	2	-	27
	MISC. CYANIDE	-	-	-	1	-	-	-	-	1	2
	HYDROCHLORIC ACID	-	-	-	-	4	1	-	1	2	8
	CHROMIC ACID	-	-	-	-	-	-	-	-	1	1
	FLUOBORIC ACID	-	-	-	-	-	-	-	-	1	1
	NITRIC ACID	-	-	-	3	4	-	-	-	1	8
	SULPHURIC ACID	-	-	-	-	5	-	-	-	-	5
	SODIUM CYANIDE	-	-	-	2	4	2	-	-	1	9
	CAUSTIC SODA	-	-	-	4	4	-	1	-	2	11
	SODIUM SULPHATE	-	-	-	-	1	-	-	-	-	1
	DETERGENTS	-	-	-	-	1	-	-	-	-	1
PASSIVATING	MISC. AND TRADE NAME	-	-	-	3	1	-	-	-	1	5
	MISC. DICHROMATE	-	-	-	-	2	-	-	-	-	2
	CHROMIC ACID	-	-	-	-	2	-	-	-	-	2
	DICHROMIC ACID	-	-	-	-	1	-	-	-	-	1

TABLE A.14. (CONT'D)

PROCESS	MAIN CHEMICAL	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
PASSIVATING	NITRIC ACID	-	-	-	8	8	2	-	-	1	19
	SULPHURIC ACID	-	-	-	-	1	-	-	-	-	1
ACTIVATING	MISC. AND TRADE NAME	-	-	-	3	3	-	-	2	1	9
	MISC. CHROMATE	-	-	-	-	2	-	-	-	-	2
	CHROMIUM FLUORIDE	-	-	-	-	1	-	-	-	-	1
	MISC. ACID	-	-	-	-	2	-	-	-	-	2
	HYDROCHLORIC ACID	-	-	-	-	1	-	-	-	-	1
	NITRIC ACID	-	-	-	1	-	-	-	-	1	2
	SULPHURIC ACID	-	-	-	-	9	-	-	-	1	10
	CAUSTIC SODA	-	-	-	2	1	-	-	-	-	3
PHOSPHATING	MISC. AND TRADE NAME	-	-	-	-	3	-	-	-	-	3
	MISC. PHOSPHATE	-	1	-	10	27	1	-	2	1	42
	NITRIC ACID	-	-	-	1	-	-	-	-	-	1
	PHOSPHORIC ACID	-	-	-	-	4	-	-	-	1	5
	IRON PHOSPHATE	-	-	-	6	24	1	-	-	2	33
	ZINC PHOSPHATE	-	-	-	2	11	1	-	1	1	16
CHROMATING	MISC. AND TRADE NAME	-	-	-	-	3	-	-	-	-	3
	MISC. CHROMATE	-	-	-	11	28	1	-	3	4	47
	MISC. DICHROMATE	-	-	-	-	3	-	-	-	-	3
	CHROMIC ACID	-	-	-	5	18	-	-	-	2	25
	DICHROMIC ACID	-	-	-	-	1	-	-	-	-	1
	NITRIC ACID	-	-	-	-	-	1	-	-	-	1
	SODIUM DICHROMATE	-	-	-	-	4	-	-	1	-	5
	POTASSIUM DICHROMATE	-	-	-	-	1	-	-	-	-	1
ELECTROLESS COPPER PLAT	MISC. AND TRADE NAME	-	-	-	2	2	-	-	-	-	4

TABLE A.14. (CONT'D)

PROCESS	MAIN CHEMICAL	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
ELECTROLESS COPPER PLAT	COPPER COMPOUND	-	-	-	4	2	-	-	-	1	7
	COPPER CYANIDE	-	-	-	-	-	-	-	-	1	1
	COPPER SULPHATE	-	-	-	2	3	-	-	-	-	5
ELECTROLESS NICKEL PLAT	MISC. AND TRADE NAME	-	-	-	4	3	-	-	-	2	9
	PHOSPHORIC ACID	-	-	-	1	-	-	-	-	-	1
	NICKEL SULPHATE	-	-	-	2	4	-	-	1	-	7
BRIGHT DIPPING	MISC. AND TRADE NAME	-	-	-	1	3	-	-	-	1	5
	MISC. CHROMATE	-	-	-	-	-	-	-	-	1	1
	MISC. PHOSPHATE	-	-	-	1	1	-	-	-	-	2
	ALUMINUM COMPOUND	-	-	-	1	-	-	-	-	-	1
	MISC. ACID	-	-	-	5	1	-	-	-	-	6
	CHROMIC ACID	-	-	-	1	7	-	-	-	1	9
	NITRIC ACID	-	-	-	3	8	-	-	-	1	14
	PHOSPHORIC ACID	-	-	-	-	7	-	-	-	1	9
	SULPHURIC ACID	-	-	-	2	12	-	-	-	-	14
	MISC. AND TRADE NAME	-	-	-	3	1	-	-	-	2	6
HARDENING	MISC. CHLORIDE	-	-	-	-	1	-	-	-	-	1
	MISC. CYANIDE	-	-	-	-	2	-	-	-	1	3
	MISC. NITRATE	-	-	-	1	-	-	-	-	-	1
	SODIUM CYANIDE	-	-	-	3	3	-	-	-	-	6
	OIL	-	-	-	-	4	-	-	1	-	5
OTHER	MISC. AND TRADE NAME	-	-	-	6	25	-	-	2	3	36
	MISC. CHROMATE	-	-	-	-	-	-	-	-	1	1
	MISC. CYANIDE	-	-	-	-	-	1	-	-	-	1
	MISC. PHOSPHATE	-	-	-	-	1	-	-	-	-	1

TABLE A.14. (CONT'D)

OTHER	PROCESS	MAIN CHEMICAL	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
		MISC. ACID	-	-	-	-	2	-	-	-	-	2
		HYDROCHLORIC ACID	-	-	-	-	1	-	-	-	-	1
		CHROMIC ACID	-	-	-	1	1	-	-	1	-	3
		NITRIC ACID	-	-	-	-	2	-	-	-	-	2
		SULPHURIC ACID	-	-	-	3	3	-	-	-	-	6
		IRON CHLORIDE	-	-	-	-	-	-	-	-	1	1
		CAUSTIC SODA	-	-	-	5	8	-	-	-	1	14
		SODIUM BORATE	-	-	-	-	1	-	-	-	-	1
		ZINC CHLORIDE	-	-	-	-	1	-	-	-	-	1
		PAINTS	-	-	-	-	1	-	-	-	-	1

TABLE A.14. (CONT'D)

PROCESS	MAIN CHEMICAL	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
ELECTROCLEANING	MISC. AND TRADE NAME	-	-	-	1	21	-	-	1	1	24
	CAUSTIC SODA	-	-	-	2	6	-	-	-	2	10
	DETERGENTS	-	-	-	-	47	-	-	-	-	47
	ALKALINE CLEANERS	-	-	-	11	23	3	1	4	11	53
ETCHING	MISC. AND TRADE NAME	-	-	-	1	5	1	-	1	-	9
	MISC. ACID	-	-	-	1	2	-	-	-	-	3
	HYDROCHLORIC ACID	-	-	-	2	1	-	-	-	-	3
	CHROMIC ACID	-	-	-	1	2	-	-	1	-	4
	SULPHURIC ACID	-	-	-	-	9	-	1	-	1	11
	IRON CHLORIDE	-	-	-	-	-	-	-	-	1	1
	CAUSTIC SODA	-	-	-	4	11	1	-	1	1	18
ANODIZING:SULPHURIC	SULPHURIC ACID	-	-	-	11	24	1	-	1	3	41
ANODIZING:CHROMIC	CHROMIC ACID	-	-	-	4	9	1	-	-	-	14
LEAD PLATING	FLUOBORIC ACID	-	-	-	1	-	-	-	-	-	1
	FLUGRIC ACID	-	-	-	1	-	-	-	-	-	1
	LEAD FLUOBORATE	-	-	-	1	3	-	-	-	-	4
	LEAD HYDROFLUOSILICAT	-	-	-	1	-	-	-	-	-	1
COPPER PLATING:CYANIDE	MISC. CYANIDE	-	-	-	1	1	-	-	-	1	3
	COPPER CYANIDE	-	-	-	15	56	2	1	4	8	86
	SODIUM CYANIDE	-	-	-	13	50	2	1	4	6	76
	CAUSTIC SODA	-	-	-	13	51	2	1	4	6	77
	POTASSIUM CYANIDE	-	-	-	2	3	-	-	-	2	7
COPPER PLATING:ACID	MISC. AND TRADE NAME	-	-	-	1	-	-	-	-	-	1

TABLE A.14. (CONT'D)

PROCESS	MAIN CHEMICAL	Nfld N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
COPPER PLATING:ACID	COPPER COMPOUND	-	-	-	-	-	-	1	-	1
	COPPER FLUOBORATE	-	-	-	1	-	-	-	-	1
	COPPER SULPHATE	-	-	3	14	1	-	2	4	24
	HYDROCHLORIC ACID	-	-	-	1	-	-	-	-	1
	SULPHURIC ACID	-	-	3	13	1	-	2	4	23
NICKEL PLATING:BRIGHT	BORIC ACID	-	-	12	70	2	1	6	12	103
	NICKEL CHLORIDE	-	-	12	70	2	1	6	12	103
	NICKEL SULPHATE	-	-	14	73	3	1	6	12	109
NICKEL PLATING:SEMI-BRI	BORIC ACID	-	-	3	33	1	-	2	3	42
	NICKEL CHLORIDE	-	-	3	33	1	-	2	3	42
	NICKEL SULPHATE	-	-	3	36	1	-	2	3	45
	NICKEL SULFAMATE	-	-	3	1	-	-	-	2	6
CHROMIUM PLATING	CHROMIC ACID	-	1	12	75	2	2	9	16	117
	SULPHURIC ACID	-	1	11	75	2	2	9	15	115
TIN PLATING	MISC. AND TRADE NAME	-	-	2	10	-	-	-	-	12
	SULPHURIC ACID	-	-	1	5	-	-	-	-	6
	PHENOLSULPHONIC ACID	-	-	1	5	-	-	-	-	6
	SODIUM STANNATE	-	-	2	12	-	-	-	-	14
	POTASSIUM HYDROXIDE	-	-	2	5	1	-	-	1	9
	POTASSIUM STANNATE	-	-	3	5	1	-	-	1	10
ZINC PLATING:CYANIDE	TIN FLUOBORATE	-	-	1	1	-	-	-	-	2
	SODIUM CYANIDE	-	-	10	42	2	-	2	5	61
	CAUSTIC SODA	-	-	11	39	2	-	2	5	59
	ZINC CYANIDE	-	-	10	40	2	-	3	5	60

TABLE A.14. (CONT'D)

PROCESS	MAIN CHEMICAL	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
ZINC PLATING:NON-CYANID	MISC. AND TRADE NAME										
	MISC. CHLORIDE	-	-	-	1	5	-	-	-	-	6
	SODIUM CHLORIDE	-	-	-	-	3	-	-	-	-	3
	CAUSTIC SODA	-	-	-	-	-	1	-	-	-	3
	SODIUM ACETATE	-	-	-	-	1	-	-	-	-	1
CADMIUM PLATING	ZINC CHLORIDE	-	-	-	-	3	-	-	1	-	4
	MISC. AND TRADE NAME										
	MISC. CHLORIDE	-	1.	-	5	25	1	-	2	2	36
	MISC. CYANIDE	-	-	-	-	1	-	-	-	-	1
	CADMIUM COMPOUND	-	-	-	1	1	-	-	-	-	1
BRASS PLATING	CADMIUM CYANIDE	-	-	-	4	10	-	-	-	1	2
	CADMIUM OXIDE	-	1	-	5	24	1	-	2	2	15
	SODIUM CYANIDE	-	1	-	7	26	1	-	2	2	35
	SODIUM CARBONATE	-	1	-	5	24	1	-	2	2	39
	MISC. AND TRADE NAME										
GOLD PLATING	MISC. CYANIDE	-	-	-	3	4	-	-	1	1	9
	COPPER CYANIDE	-	-	-	-	1	-	-	-	-	1
	ZINC CYANIDE	-	-	-	1	12	1	-	-	2	15
	MISC. AND TRADE NAME										
	GOLD COMPOUND	-	-	-	1	2	1	-	-	1	4
SILVER PLATING	GOLD CHLORIDE	-	-	-	2	4	1	-	-	-	4
	GOLD CYANIDE	-	-	-	-	1	-	-	-	1	7
	POTASSIUM CYANIDE	-	-	-	4	3	1	-	-	2	10
	MISC. AND TRADE NAME										
	CAUSTIC SODA	-	-	-	3	2	1	-	-	2	8

TABLE A.14. (CONT'D)

PROCESS	MAIN CHEMICAL	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
SILVER PLATING	SILVER CYANIDE	-	-	-	7	19	3	-	-	6	35
	POTASSIUM CYANIDE	-	-	-	5	17	3	-	-	5	30
	POTASSIUM HYDROXIDE	-	-	-	5	17	3	-	-	5	30
	POTASSIUM CARBONATE	-	-	-	5	17	3	-	-	5	30
ELECTROCLEANING	MISC. AND TRADE NAME	-	-	-	1	1	-	-	-	-	2
	FLUOBORIC ACID	-	-	-	-	1	-	-	-	-	1
	PHOSPHORIC ACID	-	-	-	-	1	-	-	-	-	1
	SULPHURIC ACID	-	-	-	1	1	-	-	-	-	2
OTHER	MISC. AND TRADE NAME	-	-	-	4	9	1	-	-	-	14
	MISC. CHROMATE	-	-	-	-	1	-	-	-	-	1
	MISC. CYANIDE	-	-	-	-	-	-	-	-	1	1
	MISC. PHOSPHATE	-	-	-	-	1	-	-	-	-	1
	COPPER CYANIDE	-	-	-	-	2	-	-	-	1	3
	HYDROCHLORIC ACID	-	-	-	-	-	-	-	1	-	1
	CHROMIC ACID	-	-	-	-	2	-	-	-	-	2
	NITRIC ACID	-	-	-	-	1	-	-	-	-	1
	SULPHURIC ACID	-	-	-	1	3	-	-	-	1	5
	LEAD FLUOBORATE	-	-	-	2	-	-	-	-	-	2
	NICKEL SULPHATE	-	-	-	-	1	-	-	-	1	2
	CAUSTIC SODA	-	-	-	-	1	-	-	-	1	2

TABLE A.15. CONSUMPTION OF CHEMICALS EXPRESSED AS IONS

ION	LB/YR BY PROVINCE									
	NFLD	N.S.	N.B.	QUE	ONT	MAN	SASK	ALTA	B.C.	CANADA
CHROMIUM	-	-	-	-	402	-	-	-	-	402
ALUMINUM	-	-	-	-	-	-	-	-	-	-
CADMIUM	-	144	-	2555	15153	81	-	207	739	18879
COPPER	-	-	-	35457	205853	180	142	1164	1604	244400
GOLD	-	-	-	89	399	12	-	-	32	539
IRON	-	-	-	31504	259937	3281	-	-	13709	294769
LEAD	-	-	-	9565	1175	-	-	-	-	10740
ZINC	-	-	-	39592	246985	2713	-	719	25813	315822
TIN	-	-	-	11242	12977	222	-	-	14	24455
SILVER	-	-	-	449	5719	132	-	-	121	6421
AMMONIUM	-	-	-	281	2630	-	-	111	-	3022
CYANIDE	-	277	-	127613	422860	4093	196	2004	15034	572077
CHLORIDE	-	-	-	1242614	2427097	24535	41	39267	3292282	7025836
SULPHATE	-	1593	11874	3912914	9541527	67379	4629	18578	1466647	15025141
PHOSPHATE	-	-	-	38260	2332508	30857	-	1146	49607	2452378
NITRITE	-	-	-	-	440	-	-	-	-	440
CHROMATE & DICHROMATE	-	-	-	149657	18153	-	-	136	1	167947
CHROMIC ACID (CrO ₃)	-	980	-	250769	965969	6279	1490	34528	59264	1319279
NICKEL	-	-	-	53648	197452	4382	128	3279	11120	270009

TABLE A.16. CONSUMPTION OF METAL ANODES BY ELECTROLYTIC PROCESS

ELECTROLYTIC PROCESS	MAIN CHEMICAL IN THE BATH	METAL CONSUMPTION, LB/YR BY PROVINCE	B.C.	CANADA		
		QUE	ONT	MAN	ALTA	
LEAD PLATING	LEAD FLUOBORATE	16	2940	-	-	2956
COPPER PLATING: CYANIDE	MISC. CYANIDE	-	-	-	-	200
	COPPER CYANIDE	10677	106848	21	2695	1325
	SODIUM CYANIDE	27752	8610	140	110	108
	CAUSTIC SODA	-	60	-	-	60
	SILVER CYANIDE	-	1440	-	-	1440
	POTASSIUM CYANIDE	9600	15600	-	-	5500
COPPER PLATING: ACID	COPPER COMPOUND	-	-	-	220	220
	COPPER FLUOBORATE	-	450	-	-	450
	COPPER SULPHATE	960	107940	105	7920	3900
	SULPHURIC ACID	-	360	-	-	120825
NICKEL PLATING: BRIGHT	NICKEL SULPHATE	270731	2475260	13580	71170	66380
NICKEL PLATING: SEMI-BRI	NICKEL SULPHATE	7392	2978364	25200	40920	30000
	NICKEL SULFAMATE	1168	190	-	-	230
TIN PLATING	SULPHURIC ACID	-	1536	-	-	1536
	SODIUM STANNATE	-	9162	-	-	9162
	POTASSIUM STANNATE	11200	1075	1120	-	50
	TIN FLUOBORATE	16000	-	-	-	13445
	TIN SULPHATE	1280	1320	-	-	16000
	TIN OXIDE	-	600	-	-	2600
ZINC PLATING: CYANIDE	SODIUM CYANIDE	48480	221281	1680	-	600
	CAUSTIC SODA	5600	4800	-	-	291141
	ZINC CYANIDE	54000	255000	-	880	19400
						5800
						315680

* SEE END OF TABLE FOR OTHER PROVINCES

TABLE A.16 (CONT'D)

ELECTROLYTIC PROCESS	MAIN CHEMICAL IN THE BATH	METAL CONSUMPTION, LB/YR BY PROVINCE				
		QUE	ONT	MAN	ALTA	B.C.
ZINC PLATING:NON-CYANID	MISC. CHLORIDE	-	16848	-	-	-
	CAUSTIC SODA	-	-	1400	-	-
	ZINC COMPOUND	-	2400	-	-	-
	ZINC CHLORIDE	-	43200	-	330	-
	ZINC SULPHATE	-	1200	-	-	-
CADMIUM PLATING	AMMONIUM CHLORIDE	-	1080	-	-	-
	MISC. CHLORIDE	-	840	-	-	-
	MISC. CYANIDE	-	360	-	-	-
	CADMIUM COMPOUND	-	24	-	-	-
	CADMIUM CYANIDE	1776	43812	-	-	525
BRASS PLATING	CADMIUM OXIDE	-	1322	-	-	-
	SODIUM CYANIDE	42400	34202	76	330	2850
	MISC. AND TRADE NAME	320	-	-	-	-
	MISC. CYANIDE	-	120	-	-	-
	COPPER CYANIDE	-	13994	50	-	350
GOLD PLATING	SODIUM CYANIDE	1672	870	-	55	-
	ZINC CYANIDE	3067	60	-	-	30
	MISC. AND TRADE NAME	75	-	1	-	-
	GOLD COMPOUND	2	-	-	-	-
	GOLD CHLORIDE	-	58	-	-	-
SILVER PLATING	GOLD CYANIDE	91	576	-	-	-
	POTASSIUM CYANIDE	-	-	1	-	4
	SILVER COMPOUND	19	-	-	-	-
	SILVER CYANIDE	21	827	4	-	-
	POTASSIUM CYANIDE	208	2239	263	-	28

* SEE END OF TABLE FOR OTHER PROVINCES

TABLE A.16. (CONT'D)

ELECTROLYTIC PROCESS	MAIN CHEMICAL IN THE BATH	METAL CONSUMPTION, LB/YR BY PROVINCE					
		QUE	ONT	MAN	ALTA	B.C.	CANADA
OTHER	COPPER CYANIDE	-	919	-	-	-	919
	LEAD FLUOBORATE	16	-	-	-	-	16
	NICKEL CHLORIDE	-	-	840	-	-	840
	SODIUM CYANIDE	-	3600	-	-	-	3600
	POTASSIUM STANNATE	-	72	-	-	-	72
	TIN CYANIDE	-	400	-	-	-	400

*CONSUMPTIONS RECORDED IN OTHER PROVINCES (INCLUDED IN CANADA TOTAL)

ELECTROLYTIC PROCESS	MAIN CHEMICAL				
		NFLD	N.S.	N.B.	SASK
COPPER PLATING: CYANIDE	COPPER CYANIDE	-	-	-	100
NICKEL PLATING: BRIGHT	NICKEL SULPHATE	-	-	-	3000
CADMIUM PLATING	SODIUM CYANIDE	-	3000	-	-

APPENDIX B

REPORT OF THE PLANT POLLUTION SUB-COMMITTEE

AUTOMOTIVE PARTS MANUFACTURERS' ASSOCIATION (CANADA)

Report of the
PLANT POLLUTION SUB-COMMITTEE
Automotive Parts Manufacturers' Association (Canada)

CONTENTS

Introduction	131
Specific Areas of Study	
1. Sludges and Concentrated Wastes	132
2. Base Levels of Treatment	133
3. Best Practicable Technology	134
4. Analysis and Sampling	141
Bibliography	143
Conclusions	144
Appendix B.1	146
Appendix B.2	149

INTRODUCTION

This report co-ordinates the findings of the Automotive Parts Manufacturers' Association (Canada) Plant Pollution Sub-Committee.

The representative of Environment Canada requested the Sub-Committee concentrate its efforts in three major areas where industry input would be most beneficial.

These areas were:

- 1) Sludges and concentrated wastes
- 2) Base levels of treatment
- 3) Best practicable technology
- 4) Methods of analysis and sampling

A questionnaire (Appendix B.1) was mailed to electroplaters in Southwestern Ontario, and to other selected manufacturers who generate contaminants in their operations. This report is based primarily on this survey.

1. SLUDGES AND CONCENTRATED WASTES

Information on the handling and disposal of sludge and concentrated waste by the Metal Finishing Industry is scarce. The majority of manufacturers contacted are using contract haulers to truck sludges or concentrates to deep well disposal sites or land fill areas. In late 1973, one London manufacturing plant disposed of 8,800 gallons (40 m³) of concentrated wastes via this method at 13¢ a gallon. This cost included the pumping charge from the retention tanks in the plant, haulage and disposal charges to the Sarnia deep well disposal site. Costs up to 20¢/gal are also cited. A number of manufacturers did not know what they would do with these by-products if the disposal sites were closed.

Companies who have installed facilities to de-water sludges and concentrates are using equipment which is readily available on the market. Large horizontal pressure filters are achieving cake concentrations of 50% solids. One company reported an installed cost of \$65,000.00 for a 600 sq ft filter with a filtering volume of 400 cu ft. Another company indicated they were installing an 863 sq ft filter for approximately \$30,000.00 to \$35,000.00. Centrifuges costing \$75,500.00 are also used to de-water sludges.

De-ionizers and evaporators are being utilized to concentrate and regenerate chrome and nickel rinse solutions. Where economical, the metal is being recovered. Where it is not economical or practical, the concentrate is being disposed to deep well sites or is treated in existing treatment facilities.

Disparity was noted in local regulations which allow dumping of soluble heavy metal salts in land fill sites provided they contain 20% solids, while insoluble hydroxides at 20% are unacceptable. From the survey it was apparent most manufacturers favoured centralized reclamation and treatment facilities. However, only 61% of them favoured sharing cost of such a facility. If centralized facilities were provided, the survey showed the cost should be distributed:

- 30% to the Federal Government
- 40% to the Provincial Government
- 20% to the Industry
- 10% to Cities

We believe there is considerable work to be done in this area to resolve the problems of what to do with processing sludges and concentrated wastes. The establishment of regional industrial waste treatment plants such as CIL's Mississauga facility, could assist in reducing the sludge disposal problem.

2. BASE LEVELS OF TREATMENT

The survey replies indicated the following levels of contaminants as being practical and possible to achieve.

Copper	3 to 5 PPM
Chromium	3 to 5 PPM
Zinc	3 to 5 PPM
Nickel	5 to 10 PPM
pH Range	5.5 to 9.5
Suspended Solids	350 PPM
Cyanide	1 to 2 PPM

Data obtained on capital equipment costs to achieve these levels varied widely because of different flow rates but it does reflect the range of dollars involved to accomplish these goals with either manual, semi-automated or fully automated systems.

Operating or treatment costs also vary over a wide range but again relate the variances from plant to plant to treat the same contaminant.

<u>CONTAMINANT</u>	<u>RANGE</u>	<u>EQUIPMENT COST IN (000's)</u>	<u>OPERATING COST</u>
Copper	Less than 5 PPM	15 to 30	.30 to .40/lb
Chromium	" " 5 PPM	12 to 60	.45 to 1.50/lb
Zinc	" " 5 PPM	30 to 40	.02 to .05/lb
Nickel	" " 10 PPM	30 to 120	.25 to 1.20/lb
pH	5.5 to 9.5	8 to 70	.03 to .40/M gal.
Suspended Solids	" " 350 PPM	12 to 95	1.00/lb
Cyanide	" " 2 PPM	15 to 90	1.00 to 2.65/lb

It was the general consensus of those companies interviewed that more research was needed to determine what effects effluent contaminants have on the environment. There was some question as to whether we really

know if some of the contaminants are detrimental to the environment, or are the by-laws established to cover a particular situation in a given area.

Existing operating installations appear to be capable of meeting local contaminant levels at some particular period to time, but over a period of successive days may have violations up to 5 times the acceptable levels. Standards should be based on monthly averages to allow for fluctuations in treatment efficiencies. It is believed that technology does not exist to provide effluent with contaminant loadings below the 1 PPM level, however, reliability of treatment equipment is questioned and "compliance by dilution" would become a reality, in order to consistently achieve less than 1 PPM.

In-Plant Changes for Reduced Effluent Loadings

A "less than 1 PPM" contaminant level requirement would require a closed loop 'reclamation' treatment system on processing equipment. Since this approach is in limited use at present, the modification or replacement cost to update present processing equipment to accommodate a closed-loop system would be extensive and conceivably could cost many hundreds of thousand dollars.

3. BEST PRACTICABLE TECHNOLOGY

It is generally agreed that waste treatment costs can be lowered if you can reduce the volume of water to be treated. New installations and some recent ones can take advantage of available space and install counter-flow rinses, spray rinses and conductivity controlled rinses to minimize volume of waste water. Old established finishing facilities, however, do not usually enjoy the luxury of additional space and cannot implement all of the water saving features recommended; therefore, they are penalized with higher treatment costs.

Waste Treatment Technology

The treatment of wastes from the metal finishing industry can be grouped into 5 basic categories:

1. The destruction of cyanide
2. The reduction of hexavalent chrome

3. The neutralization of acid or alkaline wastes
4. The removal of emulsified oils and solvents
5. The removal of metal hydroxide sludges resulting from the above treatments

The following treatment procedures are considered to be the most practical at the present time. Every waste treatment facility, however, has to be studied separately and only then can a proper decision be made regarding which method or system will be most effective and economical.

Cyanide Destruction

The most widely used and most economical method for treating dilute cyanide waste is alkaline chlorination. The chlorine required for the two step reaction can be added either in the form of a gas or as sodium hypochlorite. The first step in the reaction is conversion of cyanide to the less toxic cyanate. This reaction is pH dependent and at pH's above 10 is completed in a matter of minutes.

The second step is the oxidation of cyanate to nitrogen and carbon dioxide. A pH of 8 - 9 should be maintained to ensure a proper reaction rate and prevent the formation of ammonia which occurs at lower values of pH. This method of cyanide treatment can be performed on a batch or continuous basis. On a continuous basis the oxidation of reduction potential of the solution is monitored and the required amount of chlorine is added; pH also has to be continuously monitored and should be adjusted by the addition of caustic. The two steps in the overall reduction are conducted separately with each one being individually controlled.

Treatment of concentrated cyanide wastes by this method is not recommended due to the heat of reaction involved and possibility of side reactions. A method for treating concentrated cyanide waste is electrolytic destruction, involving the destruction of cyanide by the application of electric current. This system does not lend itself to continuous operation since a batch of fairly concentrated cyanide (2 - 5 oz/gal) can take up to 15 - 20 hours to destroy. At lower levels of cyanide, this system becomes inefficient due to the decrease in

conductivity of the solution. Wastes from this system often have to undergo further alkaline chlorination treatment to ensure effluent is within regulatory limits. After the destruction of cyanide there must be provision made for removal of the metals in the waste stream. This can be accomplished by precipitation and a solids removal system.

Other methods for destruction of cyanide include ozonation, acidification, and oxidation with peroxygen and formaldehyde. These methods in general are less widely employed.

Chrome Reduction

Chrome bearing wastes are both in the trivalent (Cr^{+3}) and hexavalent (Cr^{+6}) form. The removal of chrome from the effluent involves two considerations:

1. Chemical reduction of the hexavalent chrome to the trivalent state.
2. Neutralization and precipitation of the trivalent chrome as a hydroxide.

The reducing agents normally used are sodium metabisulfite or sulphur dioxide; both produce chromic sulphate as the end product of the reaction. This reaction is carried out at a pH of 2.0 - 2.5 to ensure a rapid reaction rate and minimize the requirements for excess reducing agents.

The reduction of chrome can be carried out either on a batch or continuous basis with ORP and pH controls being part of the necessary instrumentation. The neutralization and precipitation of the trivalent chrome can be accomplished by raising the pH to 8.5 and settling or filtering the precipitated solids.

Other agents for the reduction of chrome are in use, however, they are less attractive from an economic standpoint. For example, the cost of using ferrous sulphate is about 3 times that of metabisulfite and it produces approximately $3\frac{1}{2}$ lbs. of ferric hydroxide sludge for each pound of chrome reduced.

Chrome rinses can be concentrated by evaporation to plating bath strength and then added directly to the bath. A cation exchange unit to remove metal impurities would have to be incorporated into this

system. Any chrome present in the form of CrO_3 , is an anion, and would not be removed on the cation exchange equipment.

Other Metals: Nickel, Copper, Zinc, Etc.

Metals other than chrome contained in waste streams can include nickel, iron, copper, zinc, etc. The removal of these can be accomplished as previously mentioned by pH adjustment, precipitation and liquid/solid separation. A pH of 8.5 is usually optimum for the precipitation of these various metals.

If recovery is contemplated, several methods are currently available. Ion exchange has been successfully used to remove and recover nickel and other metals from the effluent. The nickel being a cation is removed on the cation exchange resin in the hydrogen form. The nickel removed from the process water is accumulated on the exchanger sites and can be concentrated and removed as nickel sulphate, when the bed is regenerated with sulphuric acid.

The use of ion exchange involves the segregation of nickel rinses from other rinses and some attempt to minimize flow rates must be made to reduce the size of ion exchange unit and the capital and operating expense. The recovered nickel, in many cases, is in a suitable form to return directly to the plating bath. Even if no thought of nickel recovery is considered, ion exchange does provide two distinct advantages.

Neutralization

pH control of acid and alkali rinses is almost always done on a continuous basis using a pH recorder/controller which maintains pH between 6 and 9 adding either caustic soda or sulphuric acid as required. The addition of lime for pH adjustment is often considered; however, it adds to the solids removal problem with the formation of excess sludge

Oil Removal

The treatment of oils and greases can be economically accomplished by batch treatment with acid. The anionic emulsion can be acidified with sulphuric or other waste acid. This causes separation into 3 phases: the top phase is oil rich, and can be decanted or skimmed off into barrels with possible recovery, the middle phase can be sent to final neutralization and the bottom phase or sludge must be periodically withdrawn and dumped.

Small amounts of oil can be removed by activated carbon. Other methods include cracking or breaking the emulsion with salts such as magnesium sulphate (epsom salts).

Also, a number of organic chemicals are now being marketed for breaking emulsions. This is somewhat of an art since the age, contaminant level and oil content can affect the treatment necessary to obtain good oil separation.

Greases can be separated by raising the temperature to 190°F. This causes the oil and grease to separate and then the oil can be skimmed off and recovered.

Coalescers can be used to separate oil water mixtures on a continuous basis. The selection of any of the above methods largely depends on the type of oil and emulsion encountered.

Phosphate Removal

Phosphate bearing wastes can be treated by simply raising the pH to 7 or 8 and allowing the metal phosphates to precipitate by lime. The resulting sludge can be periodically removed and disposed.

Some Typical Costs Involved in Waste Treatment

Cost of	- Use of electrolytic destruction	\$0.05 - \$0.1 /lb CN
Cyanide	- Use of caustic and chlorine	1.05 - 1.65/lb CN
Treatments:	- Use of hypochlorite	2.90 - 3.50/lb CN

Although hypochlorite is a more expensive way to treat cyanide, it is often used by the smaller plater due to the problems involved in handling gaseous chlorine.

Cost of	- Use of sulphuric acid and	
Chrome	sulphur dioxide	\$0.35 - \$0.65/lb CrO ₃
Treatments:	- Use of metabisulfite	1.20 lb/CrO ₃

Equipment Limitations

It is questionable whether a conventional packaged cyanide destruction unit of the alkaline chlorination variety without full pH and ORP instrumentation could consistently achieve a level of 1.0 PPM cyanide on a continuous basis. Even with full instrumentation the pH for the two step reaction has to be rigidly controlled to ensure adequate

reaction rate. At least 10 min. reaction time for the first oxidation to cyanate and 30 min. for the cyanate destruction is essential. Most continuous units use ORP to control and/or monitor the progress of the reaction and the addition of the chlorine re-agent. However, any oxidizable organic substance will preferentially react with the chlorine and excess re-agent must be added or cyanide will remain untreated. Good mixing of the reaction mass in the entire treatment tank is imperative. Due to the fluctuations of cyanide that exists in the effluent, a recycle system could be incorporated which would return cyanide for further treatment if the required level is not attained.

A regular check for cyanide in the treated stream must be performed to ensure the system is working effectively, and cyanide is being destroyed. A 0.1 PPM regulatory requirement could only be obtained under very carefully controlled conditions assuming that treatment system has been correctly engineered, and is properly maintained.

Chrome reduction to the trivalent state is somewhat less critical, however, the same criteria as used for continuous cyanide destruction must be applied.

The precipitation of metals in the final effluent is determined by the pH and the absence of any chelating agents in the rinses. If chelating agents are present, they will effectively tie up the metals and simple pH adjustment will not allow these metals to precipitate. The degree of removal of suspended solids will be determined by the amount of retention time that is available in a settling tank or basin. With the addition of flocculent this retention time can be reduced significantly. Typically with the use of flocculents the suspended solids in the clear effluent will average 5 - 15 PPM.

The use of pressure filtration at recommended flow rates on the final neutralized waste can produce a filtrate 0 - 10 PPM suspended solids.

Based on chemical treatment procedures the approximate capital costs of semi-automated waste treatment system to handle a typical copper/nickel/chrome plating line with a combined flow of 6,000 GPH is as follows:

Cyanide Rinses (600 GPH)	\$ 30,000
Chrome Rinses (600 GPH)	20,000
Neutralization Acid/Alkali/Nickel Rinses (4,800 GPH)	8,000
Batch Dumps	7,500
Solids Removal (Pressure Filtration)	75,000
Tanks, Linings & Miscellaneous Hardware	30,000
Installation @ 10%	17,000
TOTAL	<u>\$187,000</u>

This section on 'Best Practical Technology' can only be considered as a summary or a brief descriptive outline of present treatment technology. Much more could be written and has been written on the various treatment methods. This material is readily available and would be redundant to include it in this report.

Reference: Environmental Protection Agency Technology Transfer Program

Subjects: (a) Metal Finishing Waste Treatment
 (b) Choosing the Optimum Financial Strategy for
 Pollution Control
 (c) In Process Pollution Abatement Practices
 (d) Solids Liquid Separation, Solid Concentration
 and Sludge Disposal

4. ANALYSIS AND SAMPLING

Analysis

The consensus of opinion on methods for preparation of samples is that this information is available in a number of publications such as:

- Effluent Treatment in the Metal Finishing Industry
- Analysis of Electroplating and Related Solutions
- Manual on Industrial Water and Industrial Waste Water ASTM 148-1
- Standards Methods -- Water And Waste Water

and would be considered as a reliable source for any needed information.

Atomic Absorption Spectrophotometer appears to be the preferred type of equipment for analyzing metals in effluent samples. 'Standard Methods' P. 215, shows a table for precision and accuracy of A.A. units when used in relatively low PPM concentrations.

The error, which the article indicates, is significant and must be considered when establishing legislation. For example: A typical effluent sample was split three ways, one going to the city, one to an independent laboratory, and the other retained by the processing company. A comparison of the reports showed a variance of up to 100% on individual readings. Two of the samples were analyzed on identical equipment.

The precision, or repeatability of results with atomic absorption is considered good, compared to other methods and depends principally on the equipment used and the consistency of physical parameters.

A number of companies not large enough to have their own laboratories are utilizing independent laboratories for obtaining effluent analysis. Others rely on reports received from regulatory agencies.

Sampling of Effluent

Many suggestions were offered to the question of what constitutes a proper sampling program to determine correct contaminant levels in a plants's effluent. We felt the suggestions, other than 24 hour continuous automatic sampling, were indicative of the varying performance capabilities of waste treatment equipment and the longer or more

frequent of the sampling suggested, would allow for a better chance of the company meeting the discharge limits. Sampling for cyanide would be a continuous 2-hour sample and would require special considerations to ensure the accuracy of the cyanide content.

Precautions in Sampling

Chromium: Analyze as soon as possible after sampling. Storage in glass or plastic bottles can result in low hexavalent chromium values.

Cyanide: If sample cannot be analyzed immediately, stabilize it with NaOH to pH 12.0. If cyanogen chloride is to be determined do not add caustic. Use a tightly sealed container and analyze as soon as possible after collections.

Sampling Techniques

Quantity: Normally 2 litres is sufficient

Time Lapse: The shorter the time lapse between collection and analysis, the better, Seventy-two hours is a reasonable maximum suggested in 'Standard Methods'. Depending on the type of sample and the particular analysis to be made, the time lapse may have to be less or certain preservative measures may have to be carried out on the sample. For example, aluminum, chromium, copper, lead, iron, manganese, silver and zinc ions can be lost by absorption or ion exchange on the walls of glass containers. Absorption and precipitation can be minimized by acidifying the sample to pH 3.5 with concentrated hydrochloric or nitric acid. This obviously cannot be done if the sample is to be analyzed for such species as cyanide, cyanate or carbonate unless a separate sample is taken for these determinations. For accuracy, pH measurements should be made in the field.

Representative Samples

A grab sample should only be used to determine the composition of a stream at a given moment or the composition of a well mixed batch of effluent prior to disposal.

To approximate the composition of the effluent stream, the use of composite samples based on multiple sampling point taken over a period of time and weighted proportional to flow should be used.

If the amount of a contaminating species discharged in a certain time period is to be determined, then the flow rate and/or total volume discharged must also be known.

Sampling precautions important to the accuracy of particular methods are normally stated in the analytical method.

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"Standard Methods for the Examination of Water and Waste Water" - American Public Health Association, American Waterworks Association and Water Pollution Control Federation.

"Manual on Industrial Water & Industrial Waste Water" (second edition) - The American Society for Testing and Materials

"Atomic Absorption Spectroscopy" - Juan Ramires-Munoz, Elsevier Publishing Company

"Water Sampling Practice" - Canadian Institute on Pollution Control, 1972

Further References:

"Colorimetric Methods of Analysis" - F.T. Snell & C.T. Snell, D. Van Nostrand Company Inc. prehistoric

"Standard Methods of Chemical Analysis" - W.W. Scott, D. Van Nostrand Company Inc.

Appendix 'B' places in table form some analysis and sampling data which is relevant to this report.

CONCLUSIONS

The Sub-Committee, after receiving the data submitted, arrived at the following conclusions.

1. It is estimated that a number of small metal finishers and finishing operations within larger companies, will be forced to shut down as they will be unable to justify the expense of equipment to comply with strict regulations. It will be imperative that some financial assistance program be established to provide funds for those companies who wish to continue in the metal finishing industry. Even today, many companies are operating on borderline situations, while they investigate jobbing their finishing work out, or deciding if the finishing operation is a profitable part of their complex.
2. Major emphasis be initiated on the study of centralized centres for the treatment and disposal of sludges. This program should not be one for private industry.
3. Along with the implementation of the Federal legislation, a complete co-ordinated study be made of all outstanding effluent by-laws in order to once and for all eliminate any disparity between municipalities.
4. A manufacturing concern should not be held liable for the removal of contaminants which are present in the water which the company receives into their plant. Limits for contaminants in discharged effluent should be adjusted upwards and be the sum in PPM of the incoming contaminant plus the regulatory agency requirement.
5. It is suggested that there be a continuing program to study the effects of the contaminants on the environment, with the objective of revising the levels either upwards or downwards depending on the results of these studies. We feel it would be an injustice to have legislation which does not reflect the latest knowledge or undergo a periodic review or update.

The information presented in this report represents the efforts of a small segment of the metal finishing industry. We hope the findings are representative and valid for the whole industry and do not reflect the conclusions or opinions of only the few who provided the basic information.

We recognize the importance of the legislation being prepared and the need for sound supporting data, but found the task of gathering this needed information very difficult, and in some cases, non-existent.

We feel, however, that this report will be beneficial to Environment Canada in understanding the problems of plant pollution control within the metal finishing industry.

APPENDIX B.1

QUESTIONNAIRE

SECTION 1 - BASE LEVELS OF TREATMENT

At what levels would you suggest for the following contaminants, and could you provide a cost estimate for capital equipment and operating that would be required to maintain that level.

<u>EXAMPLE</u>	<u>Choice</u>	<u>Level</u>	<u>Capital</u>	<u>Operation</u>
Chrome	2nd	3 - 10 PPM	\$ 0	\$ 0
	1st	0 - 3 PPM	30,000.	80/lb.
	3rd	0 PPM	150,000.	120/lb.

<u>Metals</u>	<u>Choice</u>	<u>Level</u>	<u>Capital</u>	<u>Operation</u>
Copper		3 - 10 PPM		
		0 - 3 PPM		
		0 PPM		
Chromium		3 - 10 PPM		
		0 - 3 PPM		
		0 PPM		
Nickel		3 - 10 PPM		
		0 - 3 PPM		
		0 PPM		
Lead		3 - 10 PPM		
		0 - 3 PPM		
		0 PPM		
Zinc		3 - 10 PPM		
		0 - 3 PPM		
		0 PPM		
Cadmium		3 - 10 PPM		
		0 - 3 PPM		
		0 PPM		
Arsenic		3 - 10 PPM		
		0 - 3 PPM		
		0 PPM		
Silver		3 - 10 PPM		

	<u>Choice</u>	<u>Level</u>	<u>Capital</u>	<u>Operation</u>
Silver (cont'd.)		0 - 3 PPM		
		0 PPM		
Iron		3 - 10 PPM		
		0 - 3 PPM		
		0 PPM		
Mercury		3 - 10 PPM		
		0 - 3 PPM		
		0 PPM		
<u>Other Metals</u>				
P.H.		4.0-10		
		5.5-9.0		
		7.0		
Suspended		3.50-2000		
Solids		0 - 350		
		0		
Cyanide		2 - 10		
		0 - 2		
		0		
Phenglic		1 - 5 PPM		
Compounds		.1-1.0 PPM		
		0 PPM		
Other Contaminants				

SECTION II

Do you dispose of wastes containing:

Grease Oil Solvent Other

How do you dispose of waste containing oil, etc.?

Is present technology capable of producing
effluent of the quality required by
regulatory agency?

YES NO

If contaminant levels are lowered? YES NO

Comments on technology and equipment

SECTION III

How do you dispose of sludges or concentrated waste?

Land fill Disposal site (deep well) Other

What would you do with your sludges, etc., if these sources were closed?

Would you support this facility by purchasing
a share in it for construction and operation? . . . YES . . . NO . . .

Do you feel it is a Federal; Provincial; City; Industry responsibility to
provide the necessary disposal facility?

Do you have any suggestions what can be done with sludges and concentrated
wastes that would be acceptable to the environment?

SECTION IV

This section covers the necessary sampling and analysis methods to be used
by the regulatory bodies to determine if a discharge is in violation of the
legislation.

11. What type of sampling plan should be followed in collecting
and effluent sample?
 - (a) continuous 24 hour
 - (b) grab one sample
 - (c) grab samples every 4 hours over 2 days
 - (d) other
2. Analysis methods or sources?
Suggestions: (i.e. Standard Methods U.S. Water Pollution
Control Federation)

Can you specify the minimum acceptable equipment or source which should be
used in determining the contaminant levels in the discharge?

i.e. We are looking for model numbers such as an SP 1900 UNICAM ATOMIC
ABSORPTION SPECTROPHOTOMETER and/or James F. MacLaren, etc., etc.

CYANIDE

METHOD & (REFERENCE)	MINIMUM DETECTABLE QUANTITY	PRECISION	ACCURACY
1. Distillation & Titration (Standard Method P. 448) (ASTM P. 733)	0.05 mg of CN ⁻	$\pm 0.002X + 0.02$ mg/l where X is the conc. of CN ⁻ in mg/l (ref. ASTM)	coefficient of variation is $\pm 2\%$ for samples with greater than 1 mg/l of CN
2. Distillation & Chloramine T Photometric Method (Standard Methods P. 455)	0.05 mg of CN ⁻	0.03 mg at a level of 1 mg/litre. (ref. ASTM)	See "Standard Methods" P. 457

NICKEL

1. "Dimethylglyoxime" Photometric Method (ASTM P. 654)	0.01 to 5.0 mg/l range with 10 cm light path	$\pm 0.06X$ mg/l where X is the nickel conc. in mg/l.	-
2. "Heptoxime" Photometric Method (Standard Methods P. 492)	-	-	-

ZINC

1. "Dithizone" Photometric Method (Standard Methods P. 317)	1 mg.	± 0.24 mg/l for a sample containing 0.90 mg/l.	one half of 14 results were within ± 0.07 mg/l of a 0.90 mg. l sample of Zn.
2. "Zincon" Photometric Method (Standard Methods P. 320) (ASTM P. 624)	1 mg Zn	± 0.05 mg/l.	± 0.05 mg/l.
3. Polarographic Method (Standard Methods P. 322)	0.05 mg/l Zn	± 0.01 mg. l for 0.05 mg/l Zn	

LEAD

METHOD & (REFERENCE)	MINIMUM DETECTABLE QUANTITY	PRECISION	ACCURACY
1. "Dithizone" Photometric Method (Standard Methods P. 163)	2 mg.	$\begin{smallmatrix} + \\ - \end{smallmatrix} 2 \text{ mg}$	$\begin{smallmatrix} + \\ - \end{smallmatrix} 2 \text{ mg.}$

IRON

1. "Phenanthroline" Photometric Method (Standard Methods P. 156) (ASTM Reference Method P. 347)	0.02 mg/l (3 mg/l with a 10 cm light path)	Varying	Varying
2. "Tripyridine" Photometric Method (Standard Methods P. 159)	0.02 mg/l (3 mg/l with a 10 cm light path)	Varying	Varying

COPPER

1. "Cuprethol" Photometric (Standard Methods P. 130)	0.02 mg/l visually in 100 ml Nessler Tube	$\begin{smallmatrix} + \\ - \end{smallmatrix} 0.13 \text{ mg/l for a sample with } 0.42 \text{ mg/l Cu.}$	$\begin{smallmatrix} + \\ - \end{smallmatrix} 0.04 \text{ mg/l for a sample with } 0.42 \text{ mg/l Cu.}$
2. "Bathocuproine" Photometric (Standard Methods P. 133)	0.02 mg/l	$\begin{smallmatrix} + \\ - \end{smallmatrix} 0.02 \text{ mg/l for a sample with a concentration in the neighbourhood of } 0.3 \text{ mg/l Cu}$	$\begin{smallmatrix} + \\ - \end{smallmatrix} 5\% \text{ estimated}$
3. "Neocuproine" Photometric (ASTM P. 609)	0.05 mg/l	$0.008X + 0.01 \text{ mg/l}$ where X is the Cu conc. in mg/l.	

HEXAVALENT CHROMIUM

METHOD & (REFERENCE)	MINIMUM DETECTABLE QUANTITY	PRECISION	ACCURACY
1. "S-Diphenylcarbazine" Photometric (Standard Methods P. 123)	5 mg/l with a 5 cm light path	for the range below 0.4 mg/l the precision is ± 0.01 mg/l	depends on promptness of analysis and sample storage conditions. Glass and plastic containers may cause low chromate results.

TOTAL CHROMIUM

1. "Permanganate-Azide" Photometric (Standard Methods P. 124)	5 mg/l with a 5 cm light path	± 0.04 mg/l for a sample with 0.18 mg/l	± 0.05 mg/l for a sample with 0.18 mg/l Cr.
2. "Hypobromite" Photometric (Standard Methods P. 126) (ASTM P. 607)	5 mg/l with a 5 cm light path	± 0.06 mg/l for a sample with 0.18 mg/l Cr.	± 0.05 mg/l for a sample with 0.18 mg/l Cr.

CADMIUM

1. "Dithizone" Photometric (Standard Methods P. 67)	0.5 mg/l with a 2 cm light path	for a 0.5 mg/l sample precision is ± 0.03	for a 0.5 mg/l sample precision is ± 0.07 mg/l
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ALUMINIUM

1. "Auminon" Photometric (Standard Methods P. 53)	0.2 mg/l	approaches ± 0.05 mg/l in absence of fluoride and polyphosphate	approaches ± 0.05 mg/l in absence of fluoride and polyphosphate
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